MEMOIRS

OF THE

GEOLOGICAL SURVEY

OF

INDIA.

VOL. VIII.

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THOMAS OLDHAM, LL. D.,

Fellow of the Royal and Geological Societies of London; Member of the Royal Irish Academy;
Hon. Mem. of the Leop-Carol Academy of Natural Sciences; of the Isis, Dresden;
of the Roy. Geol. Soc. of Cornwall; Corr. Mem. of Zool. Soc., Lond., &c., &c.

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INTRODUCTORY NOTICE.

In issuing the eighth volume of THE MEMOIRS of the GEOLOGICAL SURVEY OF INDIA, I would very briefly ask attention to two or three points.

The extensive area described in some detail by Mr. King in the following pages forms the most southerly extension in India (so far as now known) of a very widely and largely developed series of rocks—the LOWER VINDHYAN,—the prolongation of which to the north covers immense areas in HIS HIGHNESS THE NIZAM'S dominions, and still further north, extends over a large portion of the Central Provinces' jurisdiction, and far into the North-Western Provinces. As will be seen, however, the area now described is a complete basin in itself, surrounded on all sides, and cut off from all continuations of the same formation by the older metamorphic or crystalline rocks on which this series rests. It cannot be supposed that a full knowledge of the details of the several groups or sub-divisions of this formation, and of the variations which these exhibit in thickness and in relative importance within different areas, can be acquired in any one portion of their limits, however complete in itself or extensive that portion may be. The detailed description of these rocks within the Karnúl and Kadapáh districts will, however, unquestionably prove valuable as a key to their structure elsewhere.

The Atlas of India maps of this part of the country are of old date, and never have been brought up to recent knowledge by the addition of new roads and other features. They are undoubtedly deficient both in accuracy and in detail; but, as they were the only plans which there appeared the slightest probability of our finding available for perhaps generations to come, they have been employed for the recording of the observations of the Geological Survey, so far as they go. No systematic effort has

been made to alter or improve them, excepting in a few prominent respects, as this would have occupied too much time. And if it be remembered that the area included in the small map accompanying Mr. King's report is about as great as that of England, the difficulty of dealing with imperfect data over such extended areas will be obvious.

The shorter reports which complete the volume refer to three small fields of coal-bearing rocks in Bengal. These are some of the outlying remanets of the vast denudation, which has removed so much of these valuable beds, leaving, as in some of these cases, small and now isolated areas, of little or no value commercially, but interesting as evidences of the former extension of the same deposits.

As regards the much disputed orthography of names of Indian places, I would add that while we have adopted for the names of the several formations in the Madras Presidency what appeared to be the correct mode of spelling, as Karnúl, Kadapáh, still, as on the existing maps issued under the authority and sanction of the Government other spelling has been adopted, and is, for the most part, consistently and uniformly carried out, it will be found that when speaking of these places, we have been compelled to use such spelling as is so adopted on the only authorised maps, believing that infinitely less mischief was likely to accrue from the adoption of the names as given on those maps than if we had, with an entire ignorance of the Tamil and Telugu languages to which most of these names belong, attempted to transliterate them according to any new system. No more fruitful source of confusion has ever existed than this by no means uncommon practice of altering the spelling of such names without any reference to the original word.

Where it has been practicable to use a more uniform system, with a tolerable certainty of not going still further astray, it has been done, as in the reports referring to Bengal.

T. OLDHAM.

MEMOIRS

OF THE

GEOLOGICAL SURVEY OF INDIA.

On the KADAPAH *and* KARNÚL FORMATIONS *in the* MADRAS PRESIDENCY, *by* WILLIAM KING *(Junior)*, B. A., *Geological Survey of India.*

PART I.

CHAPTER 1.—INTRODUCTION.

Object of Memoir.

This report is descriptive of a series of rocks in Southern India, which has hitherto been known by such names as the "Diamond Formation", "Clay Slate Formation", &c.,* and which, it is almost certain, has its representatives in the more central and northern parts of our Indian empire.

Rocks of Cuddapah and Kurnool Districts.

In Southern India, the series is most largely and typically developed in the Districts of Cuddapah and Kurnool, and as the old nomenclature has been found, on investigation of the rocks, to be entirely unsuitable, the names of these districts have been adopted as distinctive of the two formations under which the different groups of rocks can be classed.

* "Diamond Sandstone and Limestone" of Captain Newbold; "Old Red Sandstone" of Dr. A. T. Christie; "Clay Slate Formation" of Voysey.

Possibly representative of "Vindhyan" and lower rocks.

As to whether these rocks occur in other parts of India, there is yet much to be cleared up; but, as will be shown in future pages, there are good grounds for concluding that this may be the case, and that the KADAPAHS and KARNÚLS may eventually turn out to be partly representative of the great VINDHYAN series of India, and of a possibly underlying formation.

Area, a section of Eastern Ghats.

The area of the rocks now to be described is in shape like a peninsula, the broad part of which lies along and to the north of the left bank of the Kistnah river, having its western edge near the junction of the Toongabudra with that river, or near the town of Kurnool, and its eastern edge some thirty-four miles west of Guntoor. From this northern basis, the peninsula-shaped area extends southwards past Gooty on the west, and Nellore some distance to the east, to its apex, in the sacred hills of Tripetty and the neighbouring outliers of Narnaveram and Naggery, which lie between forty and fifty miles west-north-west of the town of Madras.

It is, in fact, a broad section of the Eastern Ghats, with the town of Cuddapah situated very nearly in its centre.

Position and extent.

Geographically, this country lies between the 13° 20′ and 17° parallels of north latitude, and between the 77° 47′ and 80° 15′ meridians of east longitude. It is about 210 miles long and about ninety-five miles wide in its longest—north-south and east-west—axes, and embraces an area very little under 13,500 square miles. It will be found on Sheets 58, 59, 75, 76, 77, and 78 of the Indian Atlas. The orthography adopted on these maps is also used in the present memoirs, although not correct, but it was found impossible to alter it uniformly.

Though this is the area of rocks to be described, it must not, at the same time, be inferred that these rocks are confined to it alone; for from what has been written by previous observers, and from an examination of the rocks which my colleague Mr. W. T. Blanford has traced down to the Godavery, there is every probability that the same deposits extend and cover large areas up to and beyond that river.

Outliers still unexplored.

It would have been all the more satisfactory for the writing out of this Memoir if the full extent of the rocks and their absolute relations with other known formations in Central India had been made out, but the complete insulation of the Cuddapah and Kurnool area, and the further delay which would be incurred by wandering over such a great extent of country, render this impossible for the present.

Present area perfect in itself.

Nevertheless, the field now to be described is a very large one and perfect in itself, and it is hardly possible that the examination of a few further outliers of only small extent would make the history of the rocks any clearer, or the comparison between these and the North Indian deposits of like kind a less difficult problem than it still is.

Previous accounts.

Already written of.

The structure and relations of the groups of rocks constituting the two formations herein referred to, have, for more than seventy years, been a fertile source of investigation and speculation with several observers, and it may be as well, before giving the results of the latest examinations, to record briefly the observations and conclusions at which they arrived.

Captain C. Mackenzie (1794).

The earliest notice to be found having reference to the Cuddapah and Kurnool rocks is in an account* of a visit which was made by Captain Colin Mackenzie

* Asiatic Researches, vol. V. p. 303.

to the Pagoda of Parawuttom* in 1794. This old writer is rather unfortunate in his description, for he makes out that this part of the country (the passage of the Kistnah through the Nullamullays) consists of granite. He, however, describes the peculiar weathered character of the surface and the internal structure of rocks (quartzites) which he saw. He speaks of iron and diamonds as being found in the same mountain range.

Dr. B. Heyne (1814).

Dr. Benjamin Heyne, of the Madras establishment (1814), wrote an "Account of the Diamond Mines in India,"† in which he describes the diamond workings of Chennoor in the Cuddapah, and of Banaganpilly in the Kurnool, Districts, besides treating of others in neighbouring districts. He gives a very tolerably accurate description of the diamond-bearing beds in these localities and of the nature of the matrix of the diamond, but does not bind himself to any views regarding the geological age of the rocks. Though he evidently thought that the condition and mode of occurrence of the diamond bed at Banaganpilly were very different from the alluvial washings of Chennoor, he nevertheless commits himself to the conclusion that all the mines which he saw are nothing else but excavations in alluvial soil. The true state of the case being that in Banaganpilly, the mines are rock workings. He also treats more generally of the whole series of rocks in another interesting paper called "A journal of a tour from Cuddapah to Hyderabad in 1809 (Tract 19)."

Dr. H. W. Voysey (1825).

In 1825, there was published a paper on the "Diamond Mines of Southern India,"‡ by Dr. H. W. Voysey, in which are given descriptions of the country and of the associated rocks. This writer was of the Wernerian school of geologists,

* Called Sreeshalum on map.

† Tracts, Historical and Statistical, on India, London, 1814 (Tract 3).

‡ Asiatic Researches, vol. XV, p. 120.

and his ideas on the geology of the country were guided by its teaching. He calls the series of rocks, with which the diamond beds are associated, the "Clay Slate Formation," and says of it—"I do not mean the Wernerian Thonschieffer, the fourth in order, of his enumeration of primary rocks, but merely a collection of rocks which I conceive to have been placed in their present situation at the same period of time."

He calls the diamond gangue a sandstone-breccia, whereas it is more of a pebble bed; but his account of the constituents of the rock is very correct. He also falls into the same confusion, in which most of the subsequent writers have involved themselves, regarding the extent and position of the band of quartzites containing the diamond beds. There are in the KARNÚL formation two well separated bands of quartzites, and the out-crops of these on opposite sides of valleys, for instance, have been taken for one and the same band. Indeed, there are numerous bands of quartzites in the lower or KADAPAH formation; and nearly all the observers have apparently taken it for granted that all these, as well as those of the KARNÚL group, are but one great series. The consequence is that Voysey, as well as the other writers, refers vaguely to the extent of the diamond-bearing beds. He makes three deductions at the end of his paper which are partly correct:—

"1*st.*—That the matrix of the diamonds produced in Southern India is the Sandstone Breccia of the Clay Slate Formation." The diamonds, at present worked, are confined to only one group of quartzite in the KARNÚL formation; but old mines appear to have been excavated indiscriminately in several bands of quartzite both in the KARNÚLS and KADAPAHS in the Kistnah District. Whether these always produced diamonds is not an ascertained fact; and some of them are in gravel deposits which very probably resulted from the denudation of the proper diamond-bearing beds in the KARNÚLS.

"*2nd.*—That those found in alluvial soil are produced from the debris of the above rock, and have been brought thither by some torrent or deluge which could alone have transported such large masses and pebbles from the parent rock, and that no modern or traditional inundation has reached to such an extent. The first part of this deduction is correct: the alluvial washings in the Cuddapah and Kurnool Districts are in deposits which are evidently derived from rocks close by the formation of which perhaps hardly required such violent forces as the writer supposes.

"*3rd.*—That the diamonds found at present in the beds of the rivers are washed down by the annual rains."

Capt. Newbold (1836).

We now come to the earlier writings of Captain Newbold, of the Madras Army, the first of which is "A glance at the Banaganpilly Jaghire, taken while passing through that territory in March 1836".* This paper is mainly descriptive of the diamond mines and the rocks in which they are worked, but the author does not put forward any views as to the age or relations of the rocks.

Before proceeding further with the papers of this indefatigable observer, it is necessary to refer to those of three other and contemporary writers.

Dr. A. T. Christie (1836).

In a paper† by Dr. Alexander Turnbull Christie, which was reprinted in the Madras Journal of 1836, the rocks of Cuddapah and Kurnool are referred to. The matter of these sketches has reference mainly to Dharwar and the adjacent

* Madras Jour., Lit. and Sci., vol. III, p. 117 (1836).

† Sketches of the Meteorology, Geology, Agriculture, Botany, and Zoology of the Southern Mahratta Country.—By A. T. Christie, M. D., (from the Edinburgh New Phil. Jour.). Madras Jour., Lit. and Sci., vol. IV, pp. 185, 452 (1836).

territories: but the author refers to these rocks under the term "Old Red Sandstone," and supposes that they are identical with like deposits in the Deccan, Vindhyan, and Gondwana ranges on both sides of the Nerbuddah, great part of Bundelkund, and possibly about Delhi. He does not consider the sandstone (quartzite) as the "old red" of English geologists, but as "identical with the old or new red sandstones of the Wernerian Geognosy."

Dr. Malcolmson (1836-37).

Dr. Malcolmson, of the Madras establishment, also about this time wrote two papers,* in both of which the Cuddapah rocks are treated of. In the first, there is only the very slightest reference made to the "Clay Slate Formation," a term to which Mr. Malcolmson objects; in so far as he thinks it would be better to characterize the limestone of this formation as "the limestone," "Cuddapah limestone," or other terms involving no opinion as to its geological relations. In the much more full and elaborate paper on the Great Basaltic District of India, the author enters largely into a description of the country about Bangnapilly, and south and east of Cuddapah. He characterizes the underlying rock at the Bangnapilly mines as schistose beds passing into limestone, whereas the limestone only occurs interstratified with rocks, which are altogether, as he would call them, schists (more properly slaty shales); the limestone bands are accidental, not distinctive. It is necessary to notice this more particularly, as subsequent writers seem to have been guided by this arrangement of Malcolmson's, and have confounded "Limestones," "Limestone and Clay Slates," and

* "Notes explanatory of a collection of geological specimens from the country between Hyderabad and Nagpur"—By J. G. Malcolmson, Assistant Surgeon, Madras establishment.—Jour., As. Soc., Beng., V, 96, reprinted in Madras Jour., Lit. and Sci., vol. IV, p. 194, July, 1836.

"On the fossils of the eastern portion of the Great Basaltic District of India"—By J. G. Malcolmson, Esq., F. G. S. Trans., Geol. Soc., London, 2nd ser., vol. V, p. 537.

"Clay Slate Series" all together and placed them under the quartzites whereon they have seen them. Still, Malcolmson seems to have had the correct idea of the relations of the beds at Bangnapilly, for he clearly saw some slight evidence of the unconformity which exists there: though he generalized too much on these relations when he saw quartzites and "Argillaceous Limestone" in other parts of the area of the Cuddapah rocks. On this account, his section at the bottom of plate XLVI* shows "Diamond Sandstone" resting on argillaceous "Limestone" throughout the whole field, which is simply the reverse of what is really the case. It had better be stated here once for all, that the lowest beds, in both the KADAPAH and KARNÚL formations, are distinctly a set of quartzite sandstones and conglomerates. He says with regard to the geological age of the "Diamond Sandstone" and "Argillaceous Limestone:" "my own conviction is that they belong to the more ancient secondary or even transition rocks." He considers that "the sandstones and limestones of Bundelkund and Malwa correspond in many particulars with those of the south of India" (p. 568).

General Cullen (1837).

The late General Cullen of Madras comes next in order as having written about these rocks†. In prosecuting a journey from Madras to Bellary, he made a couple of traverses across the Cuddapah and Kurnool country, and found that it was one of clay slate, sandstones, and limestones, with a local alternation of trap with other limestones; and this is, on the whole, nearly a true general statement of the lithology of the area. He does not enter into the question of geological age, but falls into the common error of thinking that the sandstones always cap the clay slates. He only notices with regard to the "Diamond Sandstones" that they occur near Banaganpilly.

* Trans., Geol. Soc., London, 2nd ser., vol. V.

† Trans. of the Lit. Soc., Madras, January 1837, p. 50.

After these writers, Captain Newbold again appears in the field as an accurate observer and prolific writer for many years. It is needless to refer to all his papers in detail (a list of which is appended*), there being quite sufficient matter in his "Summaries of the Geology of Southern India" to show the conclusions at which he arrived and how well he worked. It may be said with truth, that each paper is about the most clear and careful description of whatever it was intended to illustrate that has been given by any of the explorers of Southern India. Whatever errors he has fallen into are almost all due to his not having been able to make a thorough investigation of the rocks. His gravest error is that which is common to all the writers on the same subjects, *viz.*, that he places the limestones below the quartzites, yet even here he shows that glimmerings of the true state of the case were breaking in on him continually, though they were again and again obscured by his not having been able to draw a true distinction between the different bands of quartzite and limestone occurring in both the KADAPAH and KARNÚL formations. In fact, it may almost be affirmed of Captain

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* "Mineral Resources of Southern India."—Jour., Roy. As. Soc., London, vol. VII, Nos. 1 to 8, pp. 150, &c.

"Notes, principally geological, on the South Mahratta Country."—Jour., As. Soc., Bengal, vol. XIV, p. 268.

"Notes, principally geological, across the Peninsula of Southern India, from Kistapatam to Honawer."—*Ibid*, vol. XIV, p. 398.

"Summary of the Geology of Southern India."—Jour., Roy. As. Soc., London, vol. VIII, pp. 138, 213, 315, 1845.

"Notes, &c., of the Diamond and Lead Excavations of Buswapoor."—Jour., As. Soc., Bengal, vol. XV, p. 380, 1846.

"Notes, principally geological, from Gooty to Hydrabad."—*Ibid*, vol. XVI, p. 477, 1847.

"Summary of the Geology of Southern India."—Jour., Roy. As. Soc., London, vol. XI, pp. 1 and 20, 1846.

"Summary of the Geology of Southern India."—*Ibid*, vol. XII, p. 78, 1849.

The Summary of the Geology of Southern India, in the Jour., Roy. As. Soc., London, vol. VIII, 1845, is most interesting and well worthy of perusal.

Newbold, that the only work incorrectly done, or not done at all, was such as could alone be accurately determined and settled by the continuous and systematic work of men trained to such investigations. He examined the rocks quite as closely for organic remains as we have done, and with equal non-success, lingering only over some peculiar minute spherical and oval bodies in an oolitoïd silicious rock, and coming to the same doubtful conclusions, as we have been compelled to do, regarding their organic or inorganic structure.

In his Summary given in the 8th vol., Journal, Royal Asiatic Society (read 1844), he gives four sections across the Peninsula of India. Only Section 2 has reference to these rocks, and in this he, like Malcolmson, reverses the true order of superposition of limestones and quartzites. In this, the quartzites of the Eastern Ghats are also represented as lying naturally up against a sloping bottom of gneiss rocks: while for the most part along this side of the Cuddapah and Kurnool basins, the boundary is a faulted one, and the beds dip down at the older crystalline rocks. The unconformity of the two formations seems to have dawned on him on two occasions; but it was more with reference to the quartzite and limestone groups that he observed it, and here he certainly confounds the limestones of the KADAPAH rocks with those of the KARNÚL series. Finally, this cautious writer says—"with regard to the age of the Diamond Sandstone and Limestone, Geologists are of conflicting opinion;" when he goes on to give a short sketch of the views of Christie, Franklin,* and Malcolmson which need not here be repeated, as they are given above, and concludes rightly that "until the further discovery of organic remains enables the geologist to see his way more clearly, it would be advisable to refrain from any hasty and premature classification."

* Franklin does not refer to the Madras rocks, but Newbold probably refers to him here, as there is the very general view among all these writers that the Bundelkund rocks are identical with those of Cuddapah.

Dr. Carter (1853).

In 1853, another "Summary of the Geology of India"* was written by Dr. Carter of Bombay, in which, notwithstanding that the evidence was scarcely more or better than what Newbold had already brought forward, a position in the geological scale of formations is given to the KARNÚL and KADAPAH rocks. After trying to correlate all the different sandstones and limestones of India, Mr. Carter sees everything tending to the conclusion that most of the patches of limestone from Cutch to Cuddapah must be all of secondary age and possibly oolitic; while the Diamond Sandstones are "partly formed from the materials of, and therefore subsequently to, the Oolitic series."

Dr. A. von Schlagintweit (1855).

Later on, the lamented and unfortunate traveller Dr. A. von Schlagintweit came to nearly the same conclusions, but he could hardly do otherwise in the rapid journey of eighteen days which he made between Bellary and Madras in the beginning of 1855. On the strength of such a hurried examination, he published a short report† on the geology of the districts. He considers the Cuddapah rocks as of secondary age; he falls into the usual error of seeing that the sandstones rest on slates and limestones; and he is the first to discover some fossiliferous evidence, from which, of course, if it were clear, he naturally drew his conclusions as to the age of the beds containing them. This evidence was as follows:—"We found some nests of coral, some small bryozoa, and a very indistinct fragment of an Ammonite of the group of the Fimbriati (near

* Geological papers on Western India, edited by Henry G. Carter, Assistant Surgeon, H. C. S., Bombay, 1857, originally published in Jour., Bomb. Br. Roy. As. Soc., vol. V, p. 179, Jan. 1854.

† "Reports on the Proceedings of the Officers engaged in the Magnetic Survey of India."—By Adolphe, Hermann, and Robert Schlagintweit.

Nundaloor south of Cuddapah), which would lead me to believe that these secondary rocks might belong to the lower jurassic system." All the comment to be made on this evidence is that we have found no such remains. Some of the limestone beds do weather into very extraordinary coralloid shapes, but there are many reasons against these being organic. The fragment of the supposed Ammonite was "very indistinct," while it is strange that no other fragment was found then, or ever has been since. Possibly the specimen in question may have been concretionary in its structure, and covered with dendritic crystallizations. The fossil may really be in existence, but until we know more about it, it is justifiable to doubt the structure of the object which was found. Dr. A. Schlagintweit also states that he had observed an unconformity between his two groups of rocks; but unfortunately in the locality of observation given by him, the superposition of the groups is the reverse of what he states, and there is an unconformity. In a larger paper,* the same author again refers to these rocks, promulgating similar views; but he does not again refer to the supposed Ammonite among the other organic remains mentioned.

P. W. Wall, Esq. (1858-59).

In the season of 1858-59, Philip W. Wall, Esq.,† the then Mineral Viewer of Madras, examined parts of the Cuddapah and Kurnool Districts with a view to the mineral resources of that part of the country: when he sent in reports to Government. He merely treats of the rocks with reference to his special objects, and considers them as clay stones, sandstones, and limestones. He does not enter into the question of geological age.

* "Reports on the Progress of the Magnetic Survey, and of the Researches connected with it, from November 1855 to April 1856."—By Adolphe Schlagintweit. Jour., As. Soc., Beng., vol. XXVI, 1857.

† Madras Jour. of Lit. and Sci., vol. XX, New Series IV, pp. 279, 289, 1859.

Examination taken up by Geological Survey of India.

So far, the rocks of Cuddapah and Kurnool had been worked out, and published accounts of them given, when their further investigation was in time taken up by the Geological Survey of India. The present report is partly the result of these investigations which were carried out by the late Mr. Charles Æ. Oldham, Mr. R. Bruce Foote, and myself, under Mr. C. Oldham's superintendence.

The work and conclusions of these my two colleagues have therefore necessarily been largely drawn upon by me in the compilation of this essay, and these will be found in their proper place as the rocks referred to are described.

The foregoing resumé of the work of previous explorers will indicate that, in our investigation of the geological relations of the country, we have come to conclusions which are often quite opposed to those already detailed,—a result which is, after all, mainly due to the more advanced state of geological knowledge and modes of investigation thereof in the present day. None of those writers were specially trained by previous education for the work they attempted, but they appear to have earnestly done the best they could according to their opportunities,—an end which ought to be the aim of every true explorer. They nearly all risked their lives more or less for the sake of what to them was merely love of the work they took in hand, because it is utterly impossible that they could have gone into such out-of-the-way localities, as many of them did, without undue exposure to the sun, or the malarious influences of the jungle, or that they would have so exposed themselves unless urged on by true scientific fervor. Most of them made their expeditions without any serious detriment; but there was the usual accompaniment of sacrifice when it is remarked that Voysey died in his palanquin while on one of his tours, making notes and collecting specimens almost up to the last day, the lifeless body being brought on

by the bearers to the proposed end of his journey at the Howrah ghat of Calcutta. Dr. A. T. Christie, in his turn, also succumbed to fever, which was brought on by exposure during his travels in the cause of science; and later still, while our examination of these rocks was being closed up, comes the news from England of the death of our friend and colleague Mr. Charles Æ. Oldham, the seeds of whose fatal illness were, without doubt, engendered during his field life in these districts.

Chapter 2.—Physical Structure.

As compared with the rest of Southern India.

The physical aspect of the country is very different from that of the rest of Southern India. In the latter, huge, more or less radiately ribbed mountain masses, serrated and peaked ridges, conical hills, or great rounded bosses and humps rise out of and diversify extensive plains, or there is a rugged upland—still preserving a general plain-like form—dotted over with quaintly shaped assemblages of rock in addition to the ordinary hilly forms just enumerated.

The country outside.

Such is the character of the country outside the Kurnool and Cuddapah field. On the eastern side and to the south are the plains of Nellore and Madras with their ribbed and peaked ridges and hills*; while on the western side there is the rugged upland country with its "tors," and more or less rounded and angular groups of hills of Bellary and the Cuddapah sub-divisions leading up to the Mysore plateau, all of which are forms characteristic of a country of crystalline rocks.

The country inside.

But round the edges, or in the interior of the region so girded by low country and upland, quite another series of features is exhibited. The mountains are for the most part ridged in roughly

* The scarped hills and ridges of Cumbauk Droog, Narnaveram, and Naggery are capped by KADAPAH rocks, and therefore show a combination of characters belonging respectively to crystallines and rocks of clearly aqueous origin.

parallel lines, or in great domes encircled by scarped ridges, or of plateau form, or are scarped with long lines of precipitous cliff behind which are gentle and uniform slopes. The hills are flat-topped and scarped, or are parts of flat domes. The ridges are seldom irregularly serrated. These are the great general features, though there are apparent exceptions to them, as in the long eastern wall of mountain, and another range, further to the north in the Kistnah District. But these when closely looked at are found to present merely a frequent combination of the features detailed above. There is more or less radiate furrowing of the steep slopes, and there are frequent cases of irregular crest; but the scarps and parallel ridges are there: and, on the whole, the range is very different in appearance to any other long range of mountains which we have seen in Southern India. Some of the views given in this Memoir will illustrate this, especially when compared with other views of the scenery of crystalline rocks given in previous volumes* of these Memoirs.

Area crossed diagonally by a chain of valleys.

The shape or outline of the country has already been indicated as that of a peninsula. A marked feature of the area is a chain of valleys traversing it diagonally from north-north-west to south-south-east, and by taking this as a guide the remainder of the physical structure of the field may be most easily described.

The Nundyall or Khoondair valley.

The long and wide Nundyall valley forms the northern half of this chain, and it is crossed by the watershed between the Kistnah and Penn-air rivers. To the north it opens out into the Hyderabad territory; the Kistnah, Toongabudra, and Hundry all converging at this end to flow on thence as the Kistnah river alone, the town of Kurnool being in the angle of convergence of the two latter rivers. The smaller town of Nundyall is about the middle

* Mem., Geological Survey of India, vols. II and III.

of the valley to the south of the watershed,* while Cuddapah lies at the southern end.

A branch hollow to the north-west from Cuddapah, or the Taudapurtee valley.

From the latter town there is open country, or a system of valleys, leading out with a curve to the north-west into the Bellary District, in which the Penn-air and its tributary,—the Chittravutty,—converge and become the one great river which has cut through the range of hills, separating this open country from the Nundyall valley.

The Ontimitta valley.

To the east-south-east of Cuddapah the central hollow of the country is connected with the chain of minor valleys extending south-south-east to the southern extremity of the field by a narrow neck between the Bankrapett and Pollconda ranges of hills. The first of these minor hollows is that of Ontimitta, which is more or less open on its eastern side: then, after another narrow neck between the Kauculconda range and that to the west of it, the larger basin of the Chey-air opens out as the flattish country—diversified with a few hill ridges—of Nundaloor and Poolumpett. Lastly, there is another narrowing of the sides of the hollow in the Balbapully ridge beyond which is the small Balbapully jungle-covered valley where there is a narrow opening into the wide transverse valley of the Soornamookey river.

The Chey-air basin.

The Balbapully hollow.

On the southern side of this transverse valley are the southern outliers of the KADAPAH rocks.

Chain of valleys surrounded by hill country.

The system of valleys thus indicated, *viz.*, those of Nundyall, and that of Taudapurtee to the north-west, Ontimitta, Chey-air and Balbapully, may be viewed as

* Southward of Nundyall; this is generally called the Khoond-air or Khondaur valley, from the name of the main river. The great canal of the Madras Irrigation Company is constructed right down this hollow.

the skeleton of the field of KADAPAH rocks enclosed, as they are, on all sides, except towards Kurnool, Gooty in the Bellary District, and Kiskumbady at the southern end, by mountain ranges of greater or lesser extent and elevation.

Eastern ranges of the Khoond-air valley, the Nullamullays.

The Nundyall valley is enclosed on its eastern side by the Nullamullays, the most extensive range of mountains in the district, which is simply a generally north and south system of elevations and depressions except towards the north, where these become arranged concentrically around the great mountain nucleus of Eeshwarnacoopum, beyond which in the Kistnah-Nullamullays the northern extremity of the mountains assumes generally a plateau form.

Western ranges of Khoond-air valley.

The western side of the same valley is flanked by the much lower flattish ranges of the Paneum, Baitumcheroo, Ramwarum, Nosoom, and Jummulmudgoo hills, the last of which is the promontory, as it were, between the southern end of the Khoond-air hollow and that of Taudapurtee.

The Goolcheroo hills, &c., of the southern end of the Nundyall hollow, and the north-west branch of open country up to Gooty.

This last valley and the southern end of the main hollow at Cuddapah are enclosed by the Goolcheroo range of hills, and their north-western extension is a series of parallel and elevated ridges which run up to within a few miles of the Gooty opening.

The Yerramullays up to Kurnool.

North of this gap, another range of hills called the Yerramullays, which are only westward extensions of the Paneum, Baitumcheroo, and Ramwarum ranges, above referred to, extend to within a few miles of Kurnool when they drop down to the northern opening of the Khoond-air hollow.

The Bankrapett-Pollconda neck.

The final closing in of the Cuddapah end of this valley is by the Pollconda hill—part of the Goolcheroo range—; and the Bankrapett hill,—a southerly spur of the Nullamullays.

Next taking up the south-south-east tail of the chain, the Ontimitta hollow is enclosed on its western side by the southerly prolongation of Pollconda; and then the Chey-air basin and the Balbapully valley are on the same side enclosed by the long westerly up-sloping southerly continuation of the Goolcheroo range which ends in the sacred hills of Tripetty.

These ranges are the western edge of the KADAPAH rocks.

The long, though partially broken, run of westerly hills thus described as extending from near Kurnool down to Tripetty forms the western edge of the area under description. Beyond this and west of it there is a country of quite a different aspect.

The southern spurs of Nullamullays form eastern walls of Ontimitta and Chey-air hollows.

Returning again to the Nullamullay mountain range: this rugged and elevated part of the area dies away to the southward of the parallel of Cuddapah by parallel ridges which to some extent are the eastern walls of the Ontimitta and Chey-air basins.

A further long north-south valley east of Nullamullays.

Eastward of the Nullamullays and these southerly spurs, there is another long parallel valley, traversed by the Goondlacumma, Suggle-air, and last elbow of the Chey-air before it falls into the Penn-air, which extends nearly the whole length of the area under description. The large villages or towns of Cummum, Budvail, and Chittavail are in this hollow.

Walled in by the Ellaconda range or edge of Eastern Ghats.

A further eastern mountain ridge, called the Ellaconda, which is the proper edge of the Eastern Ghats, is, from opposite Cummum down to the southern extremity of the field, the eastern wall of this valley, and likewise the seaward face of the Cuddapah rocks. Beyond this, and extending to the sea, as the Nellore country, is again quite a different form of country to that inside this mountain wall.

A mid ridge of this valley eventually with the southern extremity of the Ellacondas becomes the enclosing wall of the southern end of field.

The Budvail and Chittavail valley is ribbed up its middle by further minor ridges, which, however, are broader and loftier in a southerly direction and eventually become one with the outer mountains when they form the eastern side of the southern part of the Chey-air basin, and the little Balbapully valley.

Valley opens out for a short time at Cummum and is then shut in again.

Opposite Cummum the Ellaconda mountains die down into the plains, and then the country opens out into the low country of the Carnatic, but it is again further south confined by low ridges, and finally shut up in an attenuated corner by the north-eastern spur of the Nullamullays and the Vinnaconda* and Suddabuttconda hill ridges.

Last valley of KADAPAH rocks.

Still further north again there is a rudely triangular hollow traversed by the Kistnah, and called the Palnád,† which is enclosed by the north-eastern spur of the Nullamullays just referred to, or the Waumyconda range, on its south-east side, the prolongation of the Suddabutt ridges on the eastern side, and the final east-north-east dyings out of the Kistnah-Nullamullays on the north or left bank of that river; and the north-eastern extremity of this ridge-enclosed Palnád is the termination in that direction of the KADAPAH and KARNÚL field, in the large frontier town of Juggiapett‡ or Batavole.

The western edge of the field.

The western edge of the field for nearly all its length is a cliffy scarp of no great height at the Kurnool end, but gradually becoming higher and higher until

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* Vinnakonda, Innaconda, Yinnacondah or Vinuconda.

† Western taluq of the Kistnah District.

‡ The locality of the well known but as yet mythical coal-field of Colonel Applegath, of the Madras Army.

in the Goolcheroo and Tripetty ranges there are vertical cliffs of from 5 to 700 feet. From the foot of this scarp there is a steepish slope to the rugged, though still flat, western upland which is the first step or terrace of the Bala Ghat or Mysore country. This upland terrace is much more evident as a country above the proper Madras low-country or Carnatic, in its southern part or below the Goolcheroo range, than it is in the Bellary District, for the traveller in passing from Madras to Bellary *viâ* Cuddapah passes over no sudden steps of elevation, the rise being gradual.

The eastern edge of the field.

The eastern edge of the field from the parallel of Cummum southwards is well defined as the Yellacondas, which rise up abruptly, from the Nellore plains, often to an elevation of 2,000 feet above the sea. The eastern face of the ridge is very rugged in precipitous and steep sided ribs and rifts of bare rock, with occasional cliffy scarps. There is, however, no well defined and continuous cliffy scarp looking out on the plains below, as is the case with the western hills. The Yellacondas are in this way almost the reverse of the Goolcheroo and Tripetty ranges, the scarps, if any, generally presenting their faces inwards to the great basin, while their steep backs slope sharply down to the plains outside. What scarps there are, are also not so well defined or conspicuous as those of the western hills, and they occasionally show on both sides of the ridge. The views of the Tripetty hills, Vencatigherry Droog, and Nagwarumconda (see Plate I), will illustrate the different aspects of the eastern and western edges of the field.

Talus at foot of this abrupt face.

A peculiar feature of the eastern face is the very wide and gently sloping talus which toes the abrupt slopes of the Yellaconda range. There is no such talus on the western or northern edges of the field.

VENKA ERRY DROOG

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NAGWARAM DROOG

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The low country outside.

The country lying outside of this peninsula of KADAPAH and KARNÚL rocks also requires some little description, as it is made up of rocks upon which the deposits of what may be called the Cuddapah Gulf were laid down, while it is also dotted at intervals by hills and ridges which are capped by outliers of the same rocks.

The Carnatic or Payan Ghat.

To the east and south of the barrier ranges of hills described above is spread the low country or plains of Guntoor, Nellore, and North Arcot, which is part of what in old times was called the Payan Ghat, or country below the Ghats, in contradistinction to the Bala Ghat, or country above the Ghats. This low country slopes gradually to the level of the eastern shores of this part of the Bay of Bengal, being at first, or in the neighbourhood of the mountains, fringed at intervals with flat topped and ridgy hills, the southernmost of which make up the rather extensive group of the Narnaveram and Calastry hills, with their grand scarps and lofty cliffs crowning the basement slopes.

This group of hills is separated from the southern extremity of the main area by the wide valley of the Soornamookey river, at the western end of which a ghat or ascent leads by the Nagaputla Pass up to the edge of the great Mysore plateau, or, as stated above, the Bala Ghat; and it is this upland country which lies at the base of the western hill barrier.

The Mysore plateau.

This western terrace of upland is likewise a great plain, though very different from that of the coast. It is more broken up by stream valleys, more undulating, and is everywhere dotted over with numerous rocky bosses and humpy masses of hill, or with occasional long ridges, having wall-like and serrated crests, standing out with peculiar conspicuousness.

Sectional profile of country.

The reader may now possibly make out from the foregoing descriptions that any section run across this area of country would present a tolerably general form of outline. Thus, starting from the sea-ward side, a run of low country (the Nellore District) up to a ridge of hills (the Yellacondas); then, with increasing elevation, a short series of flats with separating ridges' succeeded by a mountain range (the Nullamullays), beyond which comes a wide depression (to the north of Cuddapah, the valley of the Khoond-air, and the chain of valleys to the south-east of it), which is again flanked by a more or less irregular series of elevations (the Yerramullays and their southern extensions) until the section ends in a scarped face to the west, below which is the upland terrace of the edge of the Mysore plateau.

General height of country.

The general elevation of the country showing this east and west superficial profile never rises over 1,750 feet; but there are plateaux, mountain ranges, and peaks which are much higher, the loftiest of these last being over 3,000 feet.

Outline shown by profile sections.

Perhaps, a few examples of profile sections, like the general one sketched in the last paragraph, may best illustrate the different elevations of the country. The accompanying sections (Fig. 1, Nos. 1, 2, 3, 4) are taken across the most illustrative parts of the area, and are at right angles to the longitudinal axis; while north and south sections may be easily built up by the reader from these and from the map of the country which accompanies the present report.

Kurnool profile section.

Section No. 1 is run through the town of Kurnool due east. It has already been described how the middle depression or Khoond-air valley has in this neighbourhood opened out north and north-west into the Hyderabad territory, while

the western mountains or Yerramullays have only commenced to rise up from the plains to the east of Kurnool,—a feature which is paralleled by a like sinking down of the easternmost ridge of the Eastern Ghats into the plains of Nellore. Consequently, this section shows no scarped or hill ridge boundary either on the western or eastern edges, respectively, of the area. Kurnool is from 900 to 950 feet above the sea, but eastward of that town there is a gradual rise of country, only broken by the low Gardymuddagoo ridge, to the foot of the Nullamullays, where a height of nearly 1,000 feet is obtained. Then there is a grand rise up to the summit of the dome-shaped mountain of Eeshwarnacoopum, which is certainly over 3,000 feet. From the pyramidal summit of this mountain there is a long and quick descent to a low valley of about 1,000 or 1,200 feet above the sea, which is only separated from the great plains of Nellore by the Soonkasla ridge of 1,600 feet, and two further parallel and lower ones. Outside of these, there is an elevation of about 900 feet, which becomes lower and lower as the coast is approached.

Paipully section.

The next section, No. 2, is much more in accordance with the outline of surface of the greater portion of our area, and is drawn through Paipully, which is about the most elevated town of any importance in the Kurnool District. Paipully* is near the eastern edge of the Mysore plateau, which here runs up to the base of the western boundary hills at about two and half miles from the town. Here there is a low but distinctly scarped ridge of from 150 to 200 feet high. On passing over the ridge, there is a very sudden descent of about 550 feet into a valley backed by a series of parallel ridges, which are the southerly prolongation of the Yerramullays; only the contour of these rises up by a series of terraces to another low

* "Paipílli, 15°14′; 77°45′ in Maissúr, 10 miles N. E. of Gúti. 1,716 ft. Schl. Ad. 1,750 ft. Cull." (De Schlagintweit's India and High Asia. Text., vol. II, p. 227). I have taken Genl. Cullen's height of 1,750 feet, as it is much nearer my own observations. Called Pyapully, Papully, Paipully.—W. K.

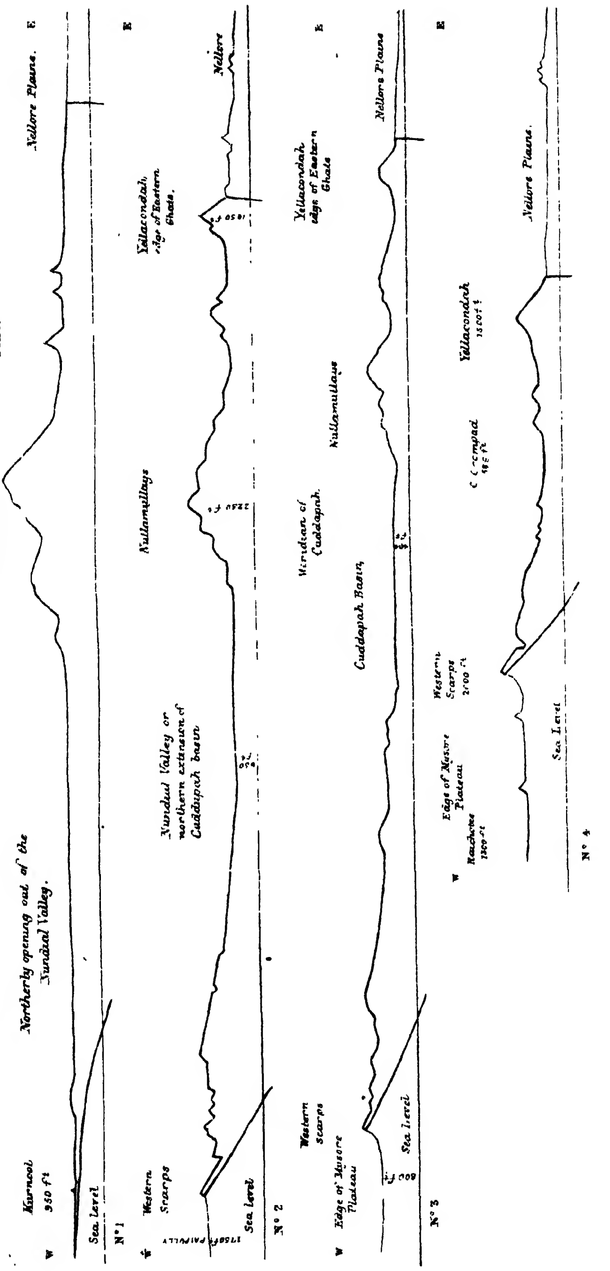

Fig. 1. Sectional contours of the area of KADAPAH and KARNÚL formations. Horizontal scale, 16 miles = one inch: Vertical scale, 6,000 feet = one inch.

scarp (at about the same level as the first from Paipully) or edge of the Oopalpad plateau, which gently descends to and flanks the Khoond-air valley. The flat bottom of this great hollow averages from 6 to 800 feet above the sea. The Nullamullays are then reached, and they rise up in sharp undulations to a height of 2,250 feet; to descend again with less rapid sweeps to the long north and south set of Kullsapawd and Porenaumlah* valleys with their intermediate ridges, which are only separated from the plains of Nellore by the Yellaconda. The crest of the fringing ridge of the Eastern Ghats is 1,000 feet or so above the sea at this point; and at 800 feet below, the Nellore plains begin to slope away towards the coast.

Cuddapah section.

The next section, No. 3, is taken along a parallel of latitude just a few miles north of Cuddapah† town. Here the great central valley is very apparent, showing a plain of from 450 to 500 feet elevation; the edge of the Mysore plateau is 800 feet above the sea, and the western scarp overlooking it rises up in the Pollconda Trigonometrical Station to about 2,000 feet. On the eastern side of the Cuddapah basin, the Nullamullays decrease in elevation as they are traced southwards; while the Yellaconda ridge is very low, the gap through which the Penn-air river flows being near this point. Beyond this the Nellore country commences to slope away from the basis of the hills, at scarcely 200 feet above the sea.

Rachotee section.

Section No. 4 is taken still further to the south, through the parallel of Rachotee‡ (on the edge of the Mysore plateau), and there the superficial outline of the country much decreases in length horizontally co-equally with the

* In the north-east part of the Cuddapah District; about 15° N. Lat., 78° 58′ E. Lon., and 660 feet (Cullen) above the sea.

† According to the late Genl. Cullen, 490 feet above the sea.

‡ In the sub-division of the Cuddapah District, about 30 miles south of the town,

rarrowing of the peninsula-shaped area, as the southern extremity is approached. The general elevation is also becoming less as the extremity is neared, for at Rachotee a height only of 1,300 feet is reached. Some fourteen miles east of the town, the western boundary hills begin to rise up and show a fine scarp of 2,000 feet, after crossing over which and a parallel of long eastward-sloping hills, the south-eastern extension of the medial chain of valleys is reached with a height of 586 feet at Chota Orampod. Then come two elevated ridges which are really the southerly tailing-off of the Nullamullays, and these are succeeded by the Ellaconda range with a height of 1,500 feet, though this varies very much to the north and south. At 900 feet below, the steeper slopes fade into the Nellore plains.

Outliers.

The Soornamookey valley, extending past the southern extremity of the Cuddapah area, is from 500 to 600 feet above the sea; and, on its southern side, the outlying group of Calastry and Narnaveram hills attains an average elevation of nearly 2,000 feet, while the peaked headland of Naggery Nose which is capped by the most southerly outlier of the rocks, is about 1,800 feet above the sea.

Eastern outliers.

The outlying ridges in the Nellore plains are of various heights, Oodagherry hill, which is not much below 2,000 feet, being the loftiest.

River system.

The whole country just described is mainly drained by two great rivers, the Kistnah and Penn-air, though the latter carries off most of the water. The Kistnah only traverses the area for a comparatively short distance, and, for this distance, is merely fed by minor streams flowing down from the very short northern slope of the watershed between the two main rivers; whereas the Penn-air, besides being fed by three large tributaries, which con-

verge within the area and have feeders of their own from this great basin, draws a large quantity of water direct from the country by means of the Khoond-air with its tributaries and the Suggle-air in the valley between the Nullamullays and Yellaconda. The only other river of any importance is the Goondlacumma,* which drains the northern and eastern third of the Nullamullays and adjacent country, and flows direct to sea by the Nellore plains.

The Kistnah.

The Kistnah runs for some short distance across the northern opening out of the Nundyall hollow, and then traverses the Nullamullays by a rather angular route flowing along the bottom of a trench which it has cut down through these mountains, which are here of a plateau or elevated basin-form, the river course having been guided by the main axis of this basin.

Varied aspect of river valley.

The course of the river through these mountains varies much in its aspect. At first, or where it enters the mountain range, it flows in a broad shallow valley, without any steep sides except at two or three points, the mountains at the same time eventually rising up to a considerable height on either side. For this distance, some miles or so, the river at flood flows along over a rocky bed between tolerably steep sloping banks: but at its lowest, when only it can be explored, it flows in a rock-cut canal or trench in long smooth reaches of water, sometimes six miles in length, with intervening rocky and gravelly or rather shingly rapids. At such a time the high water mark is very evident by the line where the trees begin to grow on either side some forty feet above the low level.

Western part of mountain course.

As a rule, throughout the mountain path of the river, there are hardly any deposits of shingle. The smooth rocky main bed of the

* This name affords a fair instance of the boundless confusion which has been introduced by different modes of spelling,—on the same sheet of the Indian Atlas, and within a few miles distance, it appears as Goondlacumma, and as Gundlacama.

river is highly polished, the surfaces of the rock having a black metallic lustre, and it is scored with short shallow grooves like wood which has been rapidly and shortly tooled with a broad gouge.*

The side streams are all deeply filled with fine alluvial mud,—a consequence of the slack water at their embouchure during the flood time.†

East of Irlaconda.

After clearing the above distance, or getting well past Irlaconda, this great river begins to flow in a much grander course, zigzagging across or through the plateau on which the famous Sreeshalum or Parrawuttom pagoda stands, in a wide and steep sided trench of nearly a thousand feet in depth. Still, even here, the cliffs do not rise up direct from the river. There is a steep slope of alluvium and debris rising a good height from even the flood mark of the river, where there is a tolerably high cliff of 200 or 300 feet, and, over this, is a second tolerably abrupt but decided slope leading up to a second run of cliffs which are the scarp of the high plateau land of Sreeshalum. The descent is, however, altogether so steep in this part of the course that there are only a few paths made down to the river in addition to two regularly built ones, which were constructed in old times for the convenience of the numerous pilgrims who annually frequent this sacred region.

This part of the river course is truly wild, solemn, and grand. The hills and trenches are tolerably well covered with low jungle, and the view from any high point is so extensive as to fade away on every side in monotonous lines of blue, purple, and grey jungle-covered ground. There is not a sign of man around,—such life is centred at the pagoda, or at certain points on the few roads to it; any sign of life there is

* More like the result of rolling shingle than of sand or small gravel.

† These side ravines are overgrown with long grass, so distinctive in popular pictures of tiger ground, which is regularly infested by these animals. Their marks are most numerous on the banks of the rivers. The grass is a variety used for making pens.

comes from the few birds, or the melancholy booing of the monkeys which frequent the river cliffs. A low murmur pervades the region, mainly from the languid flowing of the peculiarly blue-green colored water down at the bottom of the great trench, and the sighing wind through the jungle. Even when on the plateau far away from and out of sight of the river or its trench, this wonderful murmur comes sailing overhead in the most mysterious way, when scarcely the faintest breeze is apparent. In fact, it is only in the stillest times that this is farely heard, the murmurous quiet—if such a term can be used—being lost immediately any wind begins.

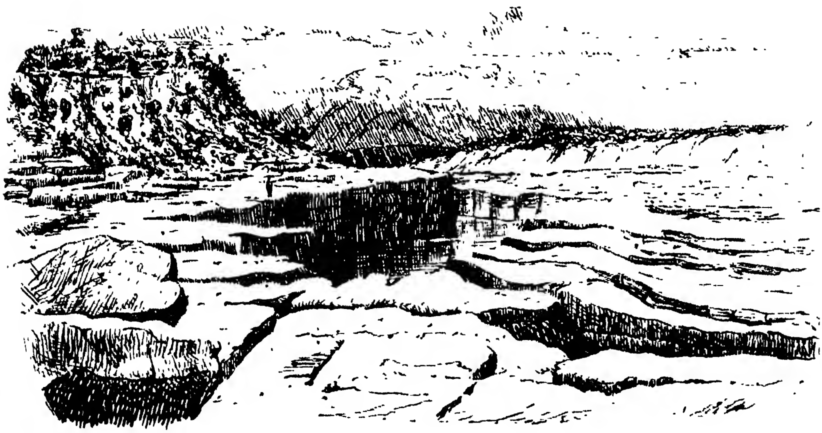

Fig 2. Kistnah river, Nullamullays. View from valley west of Allotta.

Further east, the trench-like valley ceases and the river again flows in a valley somewhat like that to the west, as in the north and south elbow from Allotta; though at the end of this course it again flows in a cliffy sided trench previous to debouching on the more open course through the Palnád.

Allotta, and the northern bend.

The annexed view (Fig. 2) is taken from the valley west of Allotta, and shows the rock-cut canal in the wider flood-water bed.

The course of the river indicated in the sheet of the Indian Atlas is wrongly delineated at several points; as, for example, around the Sreeshalum pagoda, and again in the long northern bend to the east of this. At Sreeshalum, the river is much nearer the pagodas than is shown in the map, being about three miles due west of the pagoda, and a mile and half east-north-east of it.* In the northern part of the northern bend, just before reaching the Dindee river, the Kistnah is at least two miles further east than is shown in the map.

Errors in the mapped course of river.

The peculiarly angular course of the Kistnah through this mountain region is mainly due to its having followed the great lines of weakness in the rocks, *viz.*, the east-west and north-south systems of joints: but the general course is in the axis of the trough of the plateau.

This river comes down in flood during one period of the year, *viz.*, from June to November, keeping at a tolerably high level all this time: at least this was the account given by the people of the only permanent village on its banks,

Flood time.

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* The late Captain Nelson (Madras Army), who attempted to settle and farm on the western side of the Kistnah-Nullamullays, and some of the Engineers of the Madras Irrigation and Canal Company, had made excursions into the "unsurveyed and impenetrable tract" (of the map) previous to my journeys, when they noticed that the route of the river is certainly wrongly indicated in the Atlas sheet. The region is not at all impenetrable, but there are no villages, and it is difficult to carry in supplies, or to use a horse.—W. K.

at the western end of the mountain passage. The opposite village of Bolaswarum is annually deserted, the people resorting to the low country beyond or behind the mountain to the north.

The Penn-air.

The Penn-air presents much more variety in its course, for it traverses a country which is characterized by a varied physical aspect. It first enters by a wide and open pass through the western hills some miles west of Taudapurtee, and traverses the parallel valleys and ridges beyond, after which it has a plain course to the Gundycottah range of hills, traversing it by a very grand cliffy gorge.* Having passed this barrier, there

* Captain Newbold, in one of his papers in the Jour., As. Soc., vol. XIV, p. 408, gives the following data regarding the Gundycottah gorge:—"The direct breadth of the range where intersected by the fissure is about five miles, and extreme height apparently not more than 600 feet; the extreme height of the precipices on either side, ascertained trigonometrically, is not more than 250 feet, and often not more than 80 feet. The general direction is east by north, though, in its course through the hills, it describes two salient and two re-entering angles. The bottom of the fissure is flattish, and occupied completely by the sandy bed of the Penn-air. The breadth is usually from 100 to 300 paces." (I am inclined to think Captain Newbold has under-stated the heights of the range and cliffs, and I do not think the river is ever so narrow as 100 paces.—W. K.). Concerning this fortress of Gundycottah Newbold says:—"The cliffs on the south of the pass and near its middle are ascended at the tombs of Allahabad by a steep zigzag path to the once celebrated fortress begun by the Hindu sovereigns of Bijanugger, greatly enlarged by Aurungzebe's and Kutub Shah's famous general, Mir Jumlah, and added to by Hyder and Tippoo."

"After the fall of Bijanugger in 1564, the fort was still retained by Nursing Raj, nephew of the slain Hindu monarch, Ram Raj, from whom it was taken after a severe siege by Mahommed Kuli Kutub Shah, king of Golcondah, or rather by his general, Mir Jumlah. It was subsequently annexed to the Patan Government of Cuddapah by Neknam Khan, and afterwards given up to Hyder, when he reduced this part of the Bala Ghat. It was ceded to the British by the treaty with the Nizam in 1800. The fortifications are extensive, and contain a handsome chahar minar, military magazine, and mosque, a small town, and the ruins of a temple to Mahadeo, to whose shrine, Ferishta tells us, 100,000 Hindus of Bijanugger used to make an annual pilgrimage and offer gifts of great value. Besides, the two paths by Allahabad are the other approaches to the fort, *viz.*, one by an easy ascent from Jummulmudgoo on the east, and the other from Chittiwanripully by a steep and rugged ascent just practicable for horses."

is the great central valley of the Khoond-air, which is crossed by a nearly straight south-east run to the Nullamullay mountains, in passing through which is displayed in miniature a river valley somewhat like the western part of that of the Kistnah, as it traverses the same range. Finally, the passage of the Yellaconda is made by a wide opening, the mountains rising rather leisurely from the river bed which only for part of its course is bounded by low cliffs: and then the river is free to run to the Bay of Bengal by the plains of Nellore.

The Chittravutty, Paupugnee, and Chey-air.

The three great feeders of the Penn-air, namely, the tributaries, Chittravutty, Paupugnee, and Chey-air, follow a very similar course to that which the Penn-air itself does, between the western hills and Cuddapah. They flow from the Mysore plateau, and each by a more or less narrow passage through the western hills; the most southerly, or Chey-air, having had the wider band of hills to cut through, after which their route is over stretches of plain country with occasional passing of ridges. The Paupugnee in its passage through the Goolcheroo range shows a fine gorge "with (according to Mr. C. Æ. Oldham) bold bluffs or cliffs on either side of the river, of perhaps 200 feet or more." The Chey-air receives a large tributary,—the Mundaveer or Chitt-air,—after it has entered the area of the KADAPAH rocks,—which also rises in the Mysore plateau; and thus the western wall of the area is cut through in two places for the Chey-air, giving fine examples of fissure form of denudation.

The Penn-air and its three large tributaries follow at times rather zigzag courses, and these are, in the passage of the different hill barriers, to a certain extent seemingly parallel with, or really in, great joint fissures.

The other tributaries, *viz.*, the Khoond-air and Suggle-air, are essentially long valley rivers running for the greater part of their course through plains without any obstruction.

The Goondlacumma.

The remaining river of any importance is the Goondlacumma; it shows no particular features except perhaps in the great curves described in its course, being kept well to the west, after it has got into the depressions at the base of the Nullamullays, by the northern spurs of the Yellaconda which are gradually lowering down to the plains, and then, as soon as it is free of the low barrier, winding right round in an almost opposite direction down to the Nellore coast.

Country generally dry and arid.

Notwithstanding such a fine river system, the whole country is a remarkably dry and arid one; and the influence of man is gradually assisting to make it more so. There are only two large forest-regions of any note,—the one on the Nullamullays, the other in the southern part of the field, well to the south-east of the Cuddapah basin; while even in these regions the forest is not marked by any great size of the trees, or denseness of vegetation, except in particular places where there happen to be small perennial springs of water. Over all the other ranges of hills there is a low and thin growth of jungle, showing that there is evidently every tendency, if nature were only allowed to have her own way, to a growth of low forest; but this is frustrated every season by reckless wood-cutting. The lithological constitution of the hill ranges is, however, at the same time against any very great spread or richness of vegetation.

Fertility of the high land.

Of the low grounds.

All the low grounds are extensively cultivated, and at the proper season of the year are covered with the most luxuriant crops of grain (sometimes varied with indigo) or cotton. In fact, the strange feature of a country being a desert at one time of the year and a garden at another is typically exemplified over these low grounds. The great central hollow or valley of the Khoond-air with the Cuddapah basin shows these extremes

most plainly. From November to February the country is smiling with crops in many stages of cultivation, but from that time all the beauty of the garden fades away, until in April and May the valley is nothing but a wide desert, of black and occasionally brown and red soils, over which parching winds and, later on, frequent dust storms career until the rains begin to set in by partial showers in the month of June, at which time also the great rivers are partially in flood from western rain-falls.

Land and water improvements going on.

Many of the disadvantages in the way of climate and poorness of forests are of course due to the physical structure of the country and constitution of the rocks; but many of these may also be obviated or improved by taking advantage of a knowledge of these points in the structure of the country. For instance, hitherto, though there is such a fine river system, most of, if not all, the water has been allowed to run out by the pass in the Yellacondas and by the Kistnah channel; while no account has been taken of particular areas of the rocks over which forests might be better preserved. Small attempts have, however, been made from the ancient up to

Tanks and canals.

most recent times in the way of trying to preserve water, or to retain it for purposes of irrigation: and for such works the physical structure of the country is often very well adapted. The parallel arrangement of the ridges of most of the hill ranges is peculiarly convenient for such purposes, and the narrow gorges by which they are often broken at the passage of the streams can be very often built up by bunds or dams without any very great expense or difficulty. Many such bunds were constructed in the time of the old Mogul dynasty; and the country below them, though now deserted and covered with jungle, seems to have derived great benefit from them if we may judge by the present existence of ruins of large villages and extensive overgrown areas of once wet cultivation. The Cummum tank is the most famous example of backing up water behind one of the

parallel ridges of the Nullamullays. "This fine sheet of water is about five miles long by three or four broad. It is nearly surrounded by picturesque hills, and several rocky islets stud its bosom."* It is a very old tank, and the country below it for many miles is saved from being little else than a desert.

In later times, the more extension scheme of irrigating a great area of country by means of a canal has been developed, and a grand case of this kind is being tried in the very area under description. The irrigation of the great central hollow, the Khoond-air valley, is part of this scheme; the surface is peculiarly adapted for irrigation in having an elevated ridge of low ground, running for the greater part of the length of the valley down which the canal is being constructed, so as to throw water over the country on either side. There is, besides, the cross water-shed† between the Kistnah and Penn-air, and this is so very far to the north that, if water in sufficient quantity can be brought to it, the greater part of the valley to the south may be brought under water. This water is to be found in the Toongabudra, several miles higher up the river, or to the west of the Khoond-air valley, and as it is necessarily at a higher level, there is good reason for hoping that this great engineering work will be a success worthy of all the labor and money which has been spent on it. The water of the Toongabudra is thus to be carried down to the Penn-air, north of Cuddapah, with which stream it flows until it is again brought up by a bund which is to be constructed at the mouth of the passage of the river, whence it will be distributed over the southern parts of the Nellore district.

Not only have the physical features of the country been of use in this manner, but they have also been found to be especially adapted for the more improved communication by railway. The great barrier to

* Captain Newbold, Jour., As. Soc., Vol. XV, page 392.

† The waters of the Toongabudra have since been brought over the water-shed with marked success.

the progress of a railway, running to the west or north-west from Madras, is the line of the Eastern Ghats, and the area of KADAPAH rocks has been found to come in as an easy route of ascent. It will be remembered that the mountain barriers of our area are described as having sunk down to the level of the adjacent low country at certain points, as in the neighbourhood of Kurnool, to the east of Gooty, or again at the southern extremity near Tripetty. Here, at the southern end of the area, at a level of between 500 and 600 feet, the line of railway has been able to enter on the ascent of the Ghats, and, taking advantage of the chain of valleys south-east of Cuddapah, has been able to enter the basin of that town. Thence it continues by the westerly tailing-off of this basin, and so out by the Gooty opening in the western hills to the edge of the Mysore plateau; whence in time the country may be opened up to any extent.

CHAPTER 3.—GENERAL CLASSIFICATION OF ROCKS.

Rocks of field are of two great classes.

The rocks of the field described in the preceding pages, *viz.*, the peninsula-like hill-girt basin and the belt of low country outside, may be arranged under the following heads, and belong to the two great families of—

ALTERED OR TRANSITION ROCKS and

CRYSTALLINE ROCKS.

TRANSITION and CRYSTALLINE rocks.

The first, or the KADAPAH and KARNÚL rocks, are possibly of palæozoic age; they may even be older than this; but they are, according to our present knowledge of them, azoic, for we have found no trace of life in them.

The CRYSTALLINE ROCKS, or GNEISSIC SERIES, constitute the ground-floor on which the KADAPAHS and KARNÚLS were deposited; and for the present they will only be described in this way, as occupying a narrow belt of country all round the outermost boundaries of the newer rocks.

General character of TRANSITION rocks.

The KADAPAHS and KARNÚLS consist of a great succession of clay-slates, quartzites,* limestones, and shales, with traps and trappean associates, constituting two unconformable series, the older of which is largely developed in the Cuddapah district, while the younger—if not equally extended over the Kurnool district—is very apparent in the neighbourhood of Kurnool town.

All the rocks of these two formations are more or less altered; but they still plainly show their aqueous origin,— so much so that one of their members has generally been described by nearly all the writers previously referred to as a set of sandstones; and it is quite possible, from a mere examination of many hand specimens, for an ordinary observer never to have conceived that some of the groups are altered at all. It is even almost certain that the probable analogues of these rocks in other parts of India are to a great extent not altered; under which circumstances of course, if the age of these widely separated rocks be made out as one, the term 'altered rocks' can be easily considered as of local application to parts of the one great Indian formation whatever its distinctive name may be. For the present, however, it is sufficient to know that all these rocks in the northern part of the Madras Presidency are altered: and that this general signification is only occasionally used in contradistinction to the much more altered and older crystallines of the gneissic series.

No fossils.

The strangest feature about these formations is, that they should be so entirely devoid of fossils of any kind, or even of any evidence of life, such as impressions of

* It is perhaps hardly necessary to mention that the term quartzite is here used for altered rocks of the sand group, in which the origin and structure are still apparent to the eye. The different varieties are then describable by the old names, sand, grit, conglomerate, and breccia, appended to the general term. Should the term 'quartz-rock' occur, it will never refer to silicious rock of such obviously detrital origin as those in question.

feet or like traces which might have been left on deposits often so capable of receiving and retaining them. Many of the rocks, as the limestones and shales, are such as might have been expected to contain fossil evidence of some kind; while the metamorphic action has not been always so strong as to have totally obliterated organic structure, if it had ever existed. Even in the most altered beds of conglomerate, although in freshly broken masses there is not the least trace of granular structure, much less of a pebble, still on weathered surfaces, the coarsest conglomeratic structure is plainly to be seen, many of the huge enclosed boulders being conglomeratic themselves. There are hundreds of feet of the finest laminated shales, weathered and unweathered, as recent-looking as the latest deposits of such rock, without a trace of a fossil; and the thicknesses of earthy limestone are wonderfully remarkable in this same absence of organic structure. The wind and the water only seem to have had their free play in the Cuddapah Gulf, for all that is left to us now among these rocks recording the period in which they were formed are the frequent "ripplings" wherever the early constitution or the position of the rock were such as to receive and retain the impressions which the play of the winds or waves, or both, had furrowed on them.

Having then no palæontological evidence by means of which these rocks may be compared with any others in India, or in the European geologic scale—or their own relations be traced out among themselves, we were necessarily driven to the two other data out of the three that are usually considered necessary in working out the history of the earth's crust, namely, superposition and lithological constitution, for the solving of these questions.

This is likewise the state of things in the elucidation of the great VINDHYAN FORMATION of Northern India, to which some of the rocks in question bear a strong resemblance; so that even to clear up satisfactorily whether or not there be such resemblance in fact, appears

to be really merely the work of time, until they have been traced actually into connection with one another by the rocks *in situ*, or by the finding out of known rocks which may be associated with them.

Of palæozoic age.

This has been done to a certain extent with regard to the VINDHYANS; and likewise with the KADAPAH FORMATION. The VINDHYANS have been made out by our colleagues in Bengal and Bombay to be well below, and to be separated by a greater break than exists between most European formations from, the Indian TALCHIRS, which are considered to be of carboniferous age. This then brings the VINDHYANS low down in the palæozoic period. On the other hand, we have found plant-bearing beds resting unconformably on the KADAPAH ROCKS, the vegetable remains of which Mr. Foote recognized as belonging to the Indian RAJMAHALS, and these, according to the latest researches, are of lower jurassic age.

So far, then, all that can be accurately said of the KARNÚL and KADAPAH ROCKS is, that they are greatly older than the TALCHIRS, which are certainly not younger than the carboniferous epoch of European geologists. As far as lithological resemblance goes, the structure, mineralogical composition, and general aspect of the KADAPAH formation approach closely to that of the Cambrian and Lower Silurian of Europe and England.

But to return to these formations themselves. By the tests of superposition and constitution it has been made out that the one series, the KARNÚL rests unconformably on the upturned edges of the other, the KADAPAH; and that each of these formations is divisible into groups as follows:—

KARNÚLS.

Classification of KARNÚLS.

into a set of limestones and shales which may be sub-divided and named thus—

The Khoond-air Group ... ... $\begin{cases}\text{Nundial shales,}\\ \text{Koilkoontla limestones.}\end{cases}$

Under these, a series of quartzites, or—

The Paneum Group ... ... {Pinnacled quartzites.
Plateau quartzites.

Beneath these comes a second series of limestones and shales, with local intercalation of silicious beds, or—

The Jummulmudgoo Group ... {Owk shales,
Nerjee limestones,

and, lowest of all, another set of quartzites (sandstones, pebble beds, &c.), which we may call

The Banaganpilly Group.

The *Khoond-air Group* is so called from its being largely and very nearly altogether confined to the Khoond-air valley: while the sub-divisions or members are named after two large villages in this valley—Nundyall and Koilkoontla. *The Paneum Group,* again, derives its name from the village of Paneum, close by which these quartzites occur in great force. The two sub-divisions are distinguished by the peculiarities signified by their names, the one from its forming the cappings of some remarkable plateau hills, the other from the way the rock weathers into pinnacles and buttresses. The *Jummulmudgoo Group* is named from the large village, or *tahsil* station on the west side of the Khoond-air valley: and its members are distinguished by the names of villages where they are well seen. And the name of the last group is adopted from the large town of *Banaganpilly,* where the Nawab of the jaghire of that name resides.

These four groups make up the KARNÚL FORMATION, and they are very plainly and clearly displayed in nearly every way over the present field.

Classification of KADAPAHS.

On the other hand, the upturned formation beneath is, though so extensively exposed, not at all so clear in the sequence of its grouping. Unfortunately, the 'KARNÚLS' overlie a very extensive tract of the older series, broad

patches, which cannot always be absolutely traced into correct relation with each other, being only left on either side of this covering. Under this disadvantage, the following groups of beds are advanced as representing the order of their superposition; while it will be seen how this arrangement has been adopted when the rocks are more particularly described. The series consists of four different groups of slates and quartzites, the slates being in two of these largely associated with limestone strata and with trappean rocks and their associates. The three lower of these groups are separated by unconformity and overlap, but the separation of the fourth is not at all so clear. The following is the proposed scheme of succession :—

KADAPAH FORMATION.	*Kistnah Beds* ...	... Sreeshalum quartzites.
	Nullamullay Beds	... Cumbum slates. Byrenconda quartzites.
	Chey-air Beds ...	... Poolumpett slates. Naggery quartzites.
	Paupugnee Beds ...	... Vaimpully slates. Goolcheroo quartzites.

The names of the different groups and sub-groups have been selected either from the principal mountain-ranges, rivers, or villages.

PART II.

CHAPTER 1.—THE KARNÚL FORMATION.—KHOOND-AIR GROUP.

Field of.

This series occupies only a small portion of the field of altered rocks, and is not of any great thickness. It lies mainly in the central basin, or Khoond-air valley, being confined on the east side by the bases of the Nullamullay mountains. At the southern extremity it is spread over the Cuddapah basin to the edges of the encircling hills, and thence extends northwards up to and slightly beyond the Kistnah river. On the west side it reaches from the Cuddapah basin up to the Gundycottah range of hills, and eventually overlaps them, in their northern extension, almost as far as the outer western hills, finally overlapping even these at Kurnool, beyond which town it extends for some miles to the north-west and north.

Extent and thickness.

The KARNÚLS occupy about one-third of the area of the altered rocks, giving a good superficial and vertical display, their greatest thickness being at least twelve hundred feet.

THE KHOOND-AIR GROUP.

The uppermost group of the formation is a series of altered shales and limestones, the shales being highest; though from the prevalence of the limestones and the essentially calcareous character of the shales, it might be called generally a limestone series.

The Nundial shales.

Nundial shales.

The Nundial shales, so called from the most important village in the Khoond-air valley, are essentially shaly argillaceous limestones; though they are often more shales than limestones, sometimes more limestones than shales, and

occasionally so clayey and recent-looking that the calcareous mud-stones and clayey shales of the Khoond-air valley might be supposed to belong to a much more recent set of beds than those they are lying on. The shales, &c., are of a red-purple colour generally, purple always, and are at times seamed with pale turquoise-green calcareous layers, or thin bands of limestone. Towards the northern part of their area they are crumbly and earthy, hard and soft-banded, cleaved calcareous shales—as in the long canal-cutting across the watershed between the head waters of the Khoond-air and the Bowanassi stream. In fact, towards the north this member of the *Khoondairs* becomes more compact and stony, while, as we proceed southwards, it is found to be more clayey and shaly. In the southern parts of the valley too, particularly in the Cuddapah basin, the Nundial shales are more or less cleaved, and might, down there, be called soft purple calcareous shales. They are always calcareous, that is, they effervesce on being touched with dilute nitric acid: and this is a peculiar feature as distinguishing them from the subjacent Owk shales and some of the finer shales in the KADAPAH ROCKS which assume the same red-purple color. They are easily distinguishable from the limestones below them both in color, texture, and composition; yet they graduate downwards into these by shales into shaly limestones, so that they appear to be a continuation of one deposit, of which the original materials became different as the formation increased in thickness. Indeed, it is very doubtful whether there is sufficient reason for separating this group into two members: excepting, perhaps, that they are so different looking, and so well seen in their different aspects over the valley, that it would sound absurd to hear manifestly argillaceous shales with only a small amount of lime in their constitution, called limestones, when close by there are massive beds which are as manifestly true limestones. As will be seen a little further on, there is some slight reason for the division of the group; but even as a matter of convenience, when

Character of.

describing the geology of the country, it seems just as well to have the two varieties of rock considered as different members of the one group. There is no intercalation of one with the other: the shales are always uppermost.

Lie of beds.

These uppermost strata lie in a flat basin, or are tolerably horizontal, though with gentle undulations, and curve from some short distance up against the sloping edges of the basin. There is a particular exception to this shallow trough-like arrangement along their eastern edge, where they occasionally are rather crushed up in sharper undulations, which towards the Cuddapah end are even more strongly folded, and here it is that cleavage has been most strongly superinduced. In their southern portion they are very much cleaved, as under and east of Cuddapah town, and hence are often called slates in that region. Still under Cuddapah they are generally horizontal, or not at very large angles of dip, so that the crushing force east of Cuddapah must have been so powerful (and this is shown by the lie of the rocks on this side) that cleavage was distributed among the beds. much further westward from the source of force than is the case further up the Khoond-air valley.

Distribution.

The shales are entirely confined to the Khoond-air valley and its northern extension, though they do not entirely cover this floor, having been denuded in great part on the western side about Koilkoontla, and from so much of Banaganpilly jaghire as lies in the valley. To the north, where the valley opens out towards the Hyderabad country beyond the Kistnah and Toongabudra, this sub-group thins out by denudation along, or within a short distance of, the right bank of the first river after its having been joined by the latter. All round the edges of this upper member of the group the lower rocks are to be seen cropping up in the various nullahs, and, of course, largely over the western area of denudation. About the Kistnah and its Kurnool tributaries there is a broad exposure of the lower member

of the group, as it hades out from underneath these shales. Also here and there over the middle of the Khoond-air valley, owing to undulation of the beds and subsequent denudation, this lower division, or the Koilkoontla limestone, comes to the surface.

Thickness.

The greatest observed thickness of the shales is about 350 feet; and this is perhaps the maximum of depth existing at the present day.

Localities.

The town of Cuddapah and the larger villages of Camulapoor, Dhoor, Chagulmurry, Serawul, Koilkoontla, Donapawd, Nundyall, Yellagode, Atmacoor, and Moosleemuddoo are on the Nundial shales.

Koilkoontla Limestones.

Character.

Towards their base the shales are found to shade down rapidly by thicker and more flag-like beds into dark grey and bluish sub-earthy limestones, which at first are shaly and flaggy, and likewise more earthy or clayey than the succeeding beds. These Koilkoontla limestones are essentially earthy and sub-crystalline, compact, of grey and dark-grey colors up to black, and very often in thin flags. They are well and distinctly bedded, becoming more so lower down in the group, the beds varying from six inches to a couple of feet in thickness, and these are sometimes so compacted together that it is difficult to say which are beds or masses of beds. Very often the rock is banded in alternate dark and lighter layers, of an inch or so in thickness, which are of different durability as shown by the frequently furrowed edges of the beds. Cleavage is developed in these beds at certain points, very much in the way that it shows in the shales above, though not nearly so strongly.

Deceptive organic appearances.

It has previously been stated generally that there are no evidences of organisms in any of these altered rocks; but there are, both in this and the other limestone groups, peculiar impression-like markings and minute concretionary bodies which

have attracted attention from their resemblance to fossils or impressions of such. On the surfaces of many of the coarser grey flags of the Koilkoontlas there may often be seen irregularly discoid extremely shallow depressions, from half an inch to two inches in diameter, which are of a lighter shade and smoother than the rest of the surface of the rock. These are often well separated and tolerably round in their outline, but they are generally irregularly indefinite as to their edges, and running into each other. On the corresponding under surface of the next layer, the reverses of these shallow depressions may be seen. In section these bodies show an exceedingly thin lenticular shape, and they are made up of thin laminæ of the same light-shaded clayey matter as the external surfaces. The flags in which they occur are sub-crystalline, argillaceous limestones; and it is evident that the bodies in question are merely very thin accumulations of argillaceous matter in the substance of the rocks; such, though of different form, are not even solely confined to these Koilkoontla limestones; but show likewise, though not so often in the flags of the lower or Jummulmudgoo group.

Besides the larger markings above noted, there are generally on the very same surfaces of the flags, in both groups, numerous minute papillæ which at first sight are not unlike the little crustacean *Cypris;* but these again show no organic structure, and are probably concretionary. It is perhaps hardly worth while mentioning these cases of concretionary structure in the limestone, except for the guidance of future observers, in case they are equally struck with their apparent fossil resemblance.

Variations in character of beds.

In the northern part of the field, or along so much of that part of the valley of the Kistnah and Toongabudra, this lower member of the *Khoondairs* is found to vary from its usually prevalent character of being a well-bedded limestone down to the bottom of the group. At Mooraconda, on the right bank of the Kistnah, some three miles north of the Toongabudra

confluence, the Koilkoontla limestones east of the village are seen to graduate downwards by thin sub-earthy limestone flags into the shales at the top of the following section, given by Mr. Foote as measured below the north tower of the village fort :—

	Ft.	In.
"Greenish-grey, brown, drab, and bluish-grey shales, rather silicious at the top	10	0
"Compact, dark greenish-grey silicious shales; almost a quartzite (shaly sandstone)	1	3
"Brownish, earthy shales, passing down into whitish pink and purple mottled shales	10	0
"Thin-bedded, fine-grained, greenish-grey quartzite, with small specks of black and silvery mica	6	0
"Greenish-grey and drab shales, chiefly earthy, but with some thin silicious bands	12 to 15	0

From this point southwards these shales with quartzite bands are found to be resting sometimes on quartzite and at others on limestone (of the next lower group), and extend southwards as a narrow belt almost to Nundycotecoor, cropping out at low angles from under the truer limestone beds of the Koilkoontlas, while they are not distinguishable from these by any well-marked line of demarcation. Towards the bottom the shales are found to be of white, pale-grey, greenish, and reddish colors, looking in some respects like another set of shales (Owk shales) belonging to the next lower limestone series.

A similar passing down of limestone beds by flags and shales to quartzites occurs on the opposite (left) side of the Kistnah, some distance to the west, in the neighbourhood of the villages of Pedda Duggada, Goodium, and Pedda Murroor, where a well-marked but very low-scarped outcrop of the harder limestones, shales, and for part of the distance quartzites, is seen winding about between the three villages: the grey and dirty greyish green sub-earthy shales, showing very strong in the high banks of the river south of P. Murroor, though only thinly towards P. Duggada. The quartzites are thinning out at Goodium and eventually disappear altogether to the south,

but, on the other hand, show well round towards P. Duggada, and form an extensive rising ground on the northern shore of the Goodium tank. Here the rocks are dark brown and dirty-colored somewhat ferruginous quartzites (grits and sands), with a very compact well-vitrified dark-green conglomerate of pebbles of chert and jasper. The Goodium quartzites form in fact a lenticular patch, which was probably an extensive sand bank, on what, as will be seen hereafter, was the northern shore of the Khoond-air basin. These quartzites thin out on either side of the Toongabudra-Kistnah valley, and often quite disappear to the southwards, more particularly along the banks of the first river. They show in thin compact very hard vitrified sandstone and slightly pebbly beds by another low waving scarp, on the opposite side of the Kistnah from P. Murroor, down to and under the large village of Alumpoor, and are associated at the same time with grey, buff, and reddish shales.

There is also with these, only above the buff shales, a thin bed of from nine to eighteen inches thick of lydian stone, or a compact black or nearly black silicious rock not unlike lydian stone and having a lustre, when weathered, like that of impure obsidian. Some eight miles further east, at Nundycotecoor, another, or, as I believe, the same thin bed of lydian stone crops out from under the Koilkoontla limestone, though contact is not seen, and lies immediately on fine white and pale buff shales, which are, however, traceable into the Owk shales of the limestone series below.

This occurrence of intercalated sandstones and conglomerates among shales at the bottom of the *Khoondairs* in this part of the field is interesting, as indicative of a shoreward character in the group, which is quite in accordance with the gently shelving form of country over which the strata are deposited. As will be seen further on, the lydian stone bed of Nundycotecoor, from the manner in which it occurs there, as apparently in extension of a series of quartzites to the south and

overlying the buff and white shales, seemed to belong to another group of rocks; but the more probable conclusion is, that it is merely a thin bed of silicious material, which was deposited locally at the bottom of the Koilkoontla limestones.

The limestones, then, of Alumpoor, on great flat sheets of which that town is built, would thus seem to belong to the *Khoondairs,* and they show for some short distance eastward, until they are covered up by cotton soil, of which there is a great extent over this end of the Raichoor Doab. These limestones of Alumpoor do not, however, extend westward beyond the Kurnool-Hyderabad road; the fine show of nearly horizontal limestones beyond that belonging to the lower *Jummulmudgoo* group yet to be described.

The horizontal thin flaggy beds of dark grey, nearly black, weathering light grey, sub-earthy limestones immediately west of the town of Kurnool, and in which that division of the new canal has been cut, up to the Hundry aqueduct, are also of the *Khoondairs,* the town itself being partly on lower limestones.

Lie of beds.

The lie of the Koilkoontlas is like that of the shales above them, generally horizontal, though when they come to the surface there are more irregularities in their undulations and mode of cropping up than one sees in the shales. The cotton-soil plains of the Khoond-air valley are often like an old and discarded grave-yard of tumbled tomb-stones, from the frequently irregular cropping out of thin beds and fragments of these: and in the nullahs, sharp undulations and broken-backed anticlinals are of frequent occurrence. With all this irregularity, however, if the sections be deep enough, it is generally found that at a very moderate depth the beds soon assume their horizontality, or more even undulations. I endeavour to explain this by supposing that the shaly partings (which are frequent

in the upper part of the limestones), or the thinner bands of flags, may have been partly washed, or weathered, out from underneath and between thicker beds, either by current or atmospheric action, and that the superficial beds fell in or were tumbled about.

Extent of lower member.

This lower member of the *Khoondairs* appears to be nearly always present under the shales, except perhaps along their boundary east of Koilkoontla and Banaganpilly, where unfortunately the rocks are much obscured by cotton soil. If the Koilkoontlas do exist along that edge, they must be very thin, for one passes within a very short distance from true purple shales and argillaceous limestones on to grey limestones of the lower group of *Jummulmudgoos*. Around the confluence of the Kistnah and Toongabudra, the Nundial shales have been perfectly denuded to the westward, leaving a fine display of the Koilkoontlas; Nundials being only seen in one place immediately under the second northern bastion of the Kurnool Fort.* Otherwise, the Koilkoontlas show nearly all round the edges of the shales wherever there is a nullah from the hilly sides of the basin, which has cut deeply enough through the talus of debris lying at the bases of the hills. On the north-west flank of the Oondootla plateau lying between Nundyall and Kurnool, where there has occurred perhaps the only strongly marked undulation in the whole of the KARNÚL rocks, the Koilkoontla limestones seem to have thinned out, for the purple argillaceous limestone shales run quite close up to the foot of the east-north-east end of the plateau, and apparently directly overlie quartzites, without any intervening band of limestone beds.

* I am aware that Mr. Foote is inclined to disagree with me regarding the occurrence of Koilkoontla limestones to the west of the Kistnah and its Kurnool tributaries; but I think this case of what I cannot take for anything else but the red-purple Nundial shales overlying limestones is a great point, in addition to the evident occurrence of the limestones at Alumpoor and on the left bank of the Kistnah.—W. K.

It appears then that the lower members never extended very much beyond the present boundaries,—on the western side of the Khoond-air valley at least; for there is the thinning out at Koilkoontla and Banaganpilly, as well as the just related case of the Oondootla plateau. On the eastern side of the Khoond valley there are also indications of a like thinning out of the whole group in gentle undulations up to the bases of the mountains. This is all, however, very negative evidence: and it must be remembered that the purple shales are really showing a tendency to thicken out exactly where the limestones are thinning.

Thickness.

The absolute greatest thickness of the Koilkoontlas at any point has not been made out, but there are sections showing 192 feet, and this is not the full depth in such cases. The particular case is on the east side of the Nundyall valley, in its southern half, just on the Mootialpawd stream, where there is an outcrop of banded beds of limestones.

Cleavage, &c.

It is about here, and so in a southward direction, that the sharper undulations and squeezed-up arrangement of this limestone group, and the next below it, begin to show in great force. And with this alteration in the general lie of the rocks some structures have been superinduced, which are not observable in other parts of their area. Besides being more or less cleaved, the limestones are rendered more compact and crystalline, so much so that it is often extremely difficult to recognize any difference between these Koilkoontlas and the lower Nerjee beds of the *Jummulmudgoo* group, unless the section is cleared enough to show the intermediate shales, &c. The Nerjee limestones are, as a rule, compact and more crystalline than the Koilkoontlas, and they are more distinctly banded in light and dark layers. Now, along the boundary here, the Koilkoontlas are well banded, more crystalline, and weather like the Nerjees. They are also often much stringed with white carbonate of lime, partly in the planes of cleavage and partly in those of jointing.

Koilkoontla limestones come to the surface, and are quarried around Cuddapah, Dhoor (and to the westward), Chagulmurry, up the bed of the Serawul stream, in the bed of the Khoond and the country on its right bank opposite Banaganpilly, about Bundy Atmacoor, and in the northern part of the field between Puggydeal and the Kistnah. There are, of course, numerous other localities where the rock is to be seen, but these are the most marked. More particular instances will be given further on where sections of nearly the complete series of KARNÚL rocks may be found.

Localities.

CHAPTER 2.—THE KARNÚL FORMATION.—PANEUM GROUP.

Khoondairs underlaid by quartzites.

As one passes from the wide plains of the Khoond valley north of Nundial, which are of the *Khoond-air* rocks just described, on to the rising rocky ground of the Oondootla and Poolcherla ranges of hills, it is found that the limestones and purple shales lie up over beds of quartzite. These quartzites are best displayed in the low range of hills north and west of Paneum*, and as they constitute a group of rocks distinct in every way from the limestones above and below, we distinguish them as—

THE PANEUM GROUP.

Paneum group in two members.

The quartzites so associated together are characterized by features which point them out as of two varieties, often in different localities, and occasionally at the same place. The one feature is, that certain of the beds have a peculiar way of weathering along their scarps, and over their exposed surfaces, in lines of low buttressed and pinnacled cliffs, while they are generally of a white colour; and the other is, that the rest of the beds of the group do not wear away after this fashion, but in the usual manner of horizontally bedded grit and sandstone quartzites, while these are

* Paneum, Khoond-air valley, on the road from Nundyall to Kurnool.

of a brown colour. In addition to these differences in appearance and mode of weathering in one set of the quartzites as compared with the other, there is some slight ground for considering them stratigraphically as possibly well defined members of a group. The upper may be called the pinnacled quartzites and the lower the plateau quartzites. The reason for this last appellation will show itself as the rocks themselves are treated of.

Pinnacled beds and their forms.

The pinnacled quartzites are always the uppermost of the group when both members are associated; in no case have any other beds been seen above these except those of the *Khoondairs*. They are very compact, and generally in massive beds, consisting of coarse sand of a white color, but they weather, of a pale brown shade, or are stained, and sometimes coated by the decomposition of the ferruginous element in their constitution. In drawing the hand across a freshly fractured surface there is seldom any sharp resistance, the granular structure being rounded and smooth, owing partly perhaps to the vitrified condition of the rock. Occasionally large rudely spheroidal cavities are to be seen in the lines of lamination of this exceedingly hard and compact variety of quartzite, which possibly originally contained balls of a more clayey or earthy sandstone. The pinnacled quartzites seem to be of purer silicious sands as a general rule than all the rest of the other quartzites in the KARNÚL FORMATION. They also often show less trace of a number of beds in their whole thickness, or rather they sometimes seem to be one great bed of 20 to 40 feet thick of compact quartzite, so devoid of lamination that it seems to have been deposited without any intermission; only, that other sections continually show with faint, but recognizable, lines of parting. On the other hand, an apparently very thick bed of these rocks may occur quite distinctly seamed with lines of separation other than those seen, for instance, between

layers of different texture; as though the thicker and more decidedly separable mass were part of a band of thin beds, thus:—

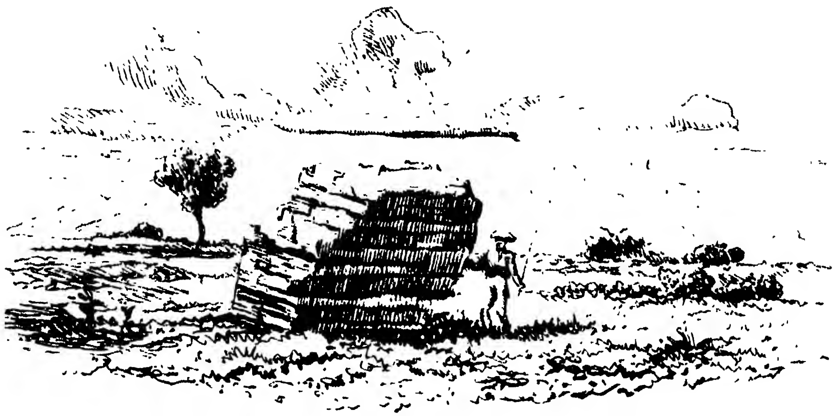


Fig. 3. Block of pinnacled quartzite, showing structure.

This seamed character of the beds is seen more particularly on the scarps of the Kortycoonta plateau, above Ramulkotta.*

Again, the pinnacled beds are occasionally well sub-divided into ordinary thick beds, as on the northern scarps of the Oopalpád plateau; but even here there is one, or perhaps two, very thick beds of the white or properly pinnacled rock. Perhaps after all, the other ordinary-looking beds may belong to the lower or plateau quartzites. The white massive beds are very strongly jointed in two prevailing lines, *viz.*, nearly east-west, north-south, vertically, and as a consequence come away in great square-sided masses, and form ravines with vertical sides.

Plateau beds and their characters.

The quartzites below the pinnacled beds which form the bottom of this group—and it is a very thin one—are, as might be expected, conglomerates, pebble-beds, coarse grits with clay-galls, and ordinary sands, which are all more or less vitrified, though at the same time very often when weathered looking like apparently unaltered deposits. The conglomerates are not common,

* About 20 miles south by west of Kurnool.

nor are they very coarse; the pebble beds and grits with layers of clay-gall cavities being more frequent. Some of the beds, more particularly the lower ones, are very ferruginous, as may be well seen in the quartzite cappings of the flat-topped hills of the Koilkoontla taluq, where the beds are quite unaltered-looking laminated ferruginous grits and sandstones, full of clay-galls in layers, and obliquely laminated. The thicker beds here are much weathered into little pits and hollows, and are full of spherical concretions of brown peroxide of iron about the size of a walnut.

It is from these peculiar flat-topped or plateau hills of the Koilkoontla taluq that the name appended to this member of the *Paneum* group has been adopted. Most of the hills detached from the main Oopalpád plateau are, in profile, like exceedingly squat truncated cones with flat tops; the capping being of these quartzites. The following sketch will give an idea of these hills:—

Fig. 1. View looking east from the Joonootla scarp of the Oopalpád plateau, showing outlying hills capped with "plateau quartzites." b, plateau quartzites, a, limestones and flags of *Jummulmudgoo* group.

One hundred feet of Paneums.

The thickness of this group is not very great, and it is not very variable, only thinning out towards its edges; but each of the members varies much in places, as one overlaps the other, the two together still keeping up the average thickness of the group; in this way each is often quite thick enough to represent the whole, by merely its own depth, one or other being altogether absent. One hundred feet appears to be about the thickness of the whole *Paneum group,* though generally the combined thickness of both members falls within this. The Oopalpád plateau is the region of the finest display of both members together, or of either singly; and the average thickness of the pinnacled beds was 50 feet, while the plateau beds were only 30 feet.

No important stratigraphic division into two members.

The sub-division of this group is really more a matter of convenience than anything else, for the pinnacled and plateau beds all seem to be part of one shallow deposit, which was formed over a wide and flat basin, though the lower beds were not of sufficient extent to cover the bottom of the basin, and the upper beds have stretched well beyond the thinning-out edge of the plateau beds in some parts of the area, or, in other words, have overlapped them. There is likewise some evidence that the pinnacled beds did not ever cover the lower ones in other parts of the field, as in the south about the Oopalpád plateau, where they are evidently thinning out rapidly over the plateau-beds, which stretch far beyond to the south and south-east in the peculiar flat-topped hills which give the name to this member of the group. It is true, however, that this evidence is very incomplete, for there is no proof here that the proper thickness of the pinnacled beds is at all represented, owing to the subsequent denudation. There is one case, close to the village of Kypaw, a couple of miles east of Banaganpilly, which seems to show pretty clearly that the lower beds have thinned out here under the Koilkoontla limestones without being accompanied by the pinnacled beds: for we have only

a thin bed of quartzite-sandstone with sandy shales to represent 20 to 30 feet of beds of the whole group some miles further west.

It would thus appear that the shallow basin of deposition had been, in the first instance, supplied with its detrital matter from some western points in the southern part of the area, and that this supply eventually ceased, when conditions became such that a large supply of other and somewhat different sand was poured in about the middle of the northern part of the area. Otherwise, there is no further evidence of any lengthened period of time having elapsed between the two kinds of sandstone deposits. There is no sign of unconformity, as of a worn surface of the lower member: the thick beds of white quartzite are lying quite evenly on the surface of the brown grits.

Region of Paneums.

This group of rocks occurs solely in the Kurnool district, on the west side of the Khoond-air valley, on and about the assemblage of hills lying between that valley and the true Yerramullays or western hills. It once formed part of a low, flattish, somewhat elliptical dome, which has since been denuded into the hill ranges of Paneum, Banaganpilly, and the Oopalpád plateau, with its outlier south of Koilkoontla. The longer axis of the ellipse lies

Mode of occurrence.

in a north-east south-west direction, striking across between Banaganpilly on the south-east side and Ramulcottah (about 18 miles south by west of Kurnool) on the north-west. At the north-east end the dome-like arrangement of strata is very well indicated; the beds of quartzite rising up as the Paneum hills from under the limestone plains of the Khoond-air valley; but denudation has cleared away a very great deal of the old southerly extremity. The edge of the dome is pretty clear at the north-eastern extremity, though denudation has only left its outcrop now standing, in one case, as a most marked 'wall'* of quartzite along the north-west flank of the Oondootla plateau, and, in another, as a gently easterly dipping outcrop in the

* See Mr. Foote's notes given further on, pp. 65—66.

plains between Paneum and Banaganpilly. The following sections show

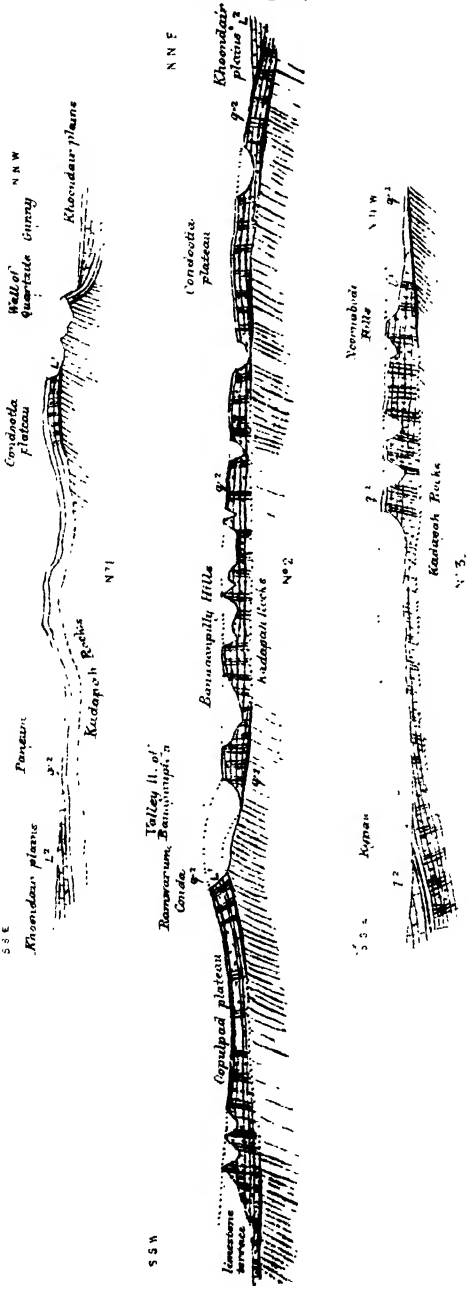


Fig. 5. Sections across the dome of Paneum quartzites. No. 1, shows a nearly perfect dome; No. 2, shows the denuded southern end; No. 3, the denudation of the sides, and the thinning out of the Paneum group under Kypaw. l2, Khoond-air group: q2, Paneum group: l1, Jummulmudgoo group: q1, Banaganpilly group.

the structure of the Paneum 'dome'. The first is run through Paneum north-west to Gunny; the second is a nearly south-south-west line from the north-east end of the dome, through the Oopalpád plateau, where the south-west end of the dome has been completely denuded; and the third through Kypaw, where the *Paneums* have thinned out north-west to the Novenabode hill.

Among the Banaganpilly hills the quartzites with their underlying rocks have been cleared away to a great extent, only the higher parts of the dome being now left as nearly flat cappings to the numerous limestone hills of that region. About here the flat-topped hills are very picturesque, and at a distance (or from the middle of the Khoond-air valley) are not unlike, in outline, some of the trap ranges figured in works of various authors on the traps of the Deccan. South-west of Banaganpilly the denudation has been so strong that the dome-like character is utterly lost, the original slopes down to the low country on all sides being quite worn away. The Oopalpád plateau with its bounding edge of scarps alone remains to indicate the former extent of these quartzites. This Oopalpád plateau is worthy of notice from its marked differences from any other of the extensive hill surfaces in the districts under description. It is the largest, though not the most perfect, plateau in the country, the most perfect flat-topped range being perhaps that four or five miles west-north-west of Banaganpilly with its thick capping of white quartzites. This of Oopalpád is not quite flat-topped, but the covering of quartzites is lying at a very low angle to the eastward, in somewhat of a basin shape, so that the land hades well up to the west-north-west and north, and runs flat out to the east on the village of Oopalpád as a centre. All round the edges of the plateau there is a sudden descent* to the low country on

Hill cappings.

Oopalpád plateau.

* To show how distinctly edged this plateau is on all sides, there is only one way of getting carts on to it, *viz.*, by the little denuded bay north-east of Goodypád on the south side; and even here the cart-traffic is only from Oopalpád down to this bay, there being an almost impassable terrace of flat beds of limestones outside of it.

the east, or to a narrow flat terrace on the other sides, and there is always a vertical scarp varying from a few feet to the extreme of nearly one hundred feet of the *Paneum* quartzites. To the west and north the plateau heads up to nearly 2,000 feet above the sea in Ramwarum-conda and the Booryal scarps. Both the pinnacled beds and the underlying quartzite sands, grits, and pebble beds are exhibited in the capping of this plateau; as also the tendency of each member, or at any rate of the lower one, to thin out towards the confines of the group. Towards the middle of the plateau, on the eastern edge, the lower sandstones thicken very distinctly, while they show very thinly along the scarps under the great buttressed beds. The pinnacled beds are quite denuded from the southern edge of the plateau and over the flat basin in which the village is built, as also from all the caps of the outlying flat-topped hills.

Mode of denudation and weathering of *Paneums*.

It is curious how such thick and hard beds of the pinnacled quartzites have been in some places, on and about this plateau, so perfectly denuded back from the scarp of the lower beds, often for a mile or so, showing on their part a second scarp bounding the terrace of lower beds, buttressed and pinnacled in the same way as the usual outer scarp of the white beds. The following sketch section of part of the Oopalpád plateau will show this terrace and scarp, as in the hills immediately north-north-west of Owk, a village just below and on the east side of the plateau.

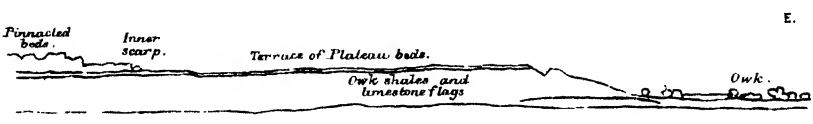
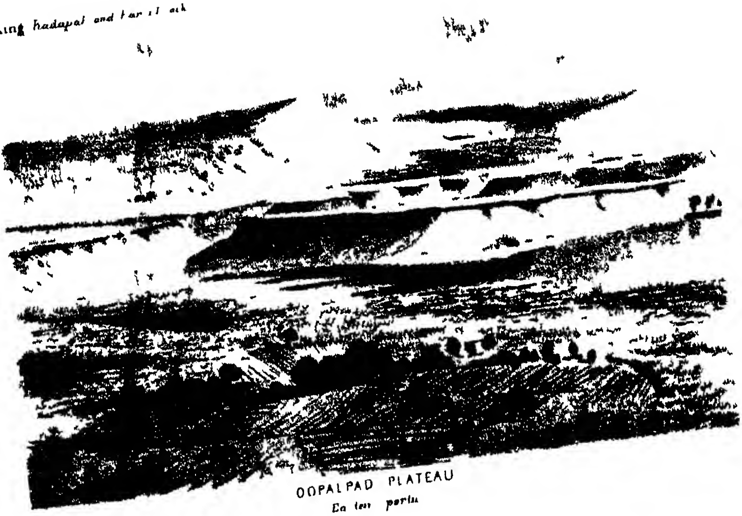


Fig. 6. Sectional outline of part of Oopalpád plateau, &c.

Here the inner scarp is from 10 to 15 feet in height, though this does not represent the thickness which the pinnacled beds originally had at this point. The pinnacled beds are much jointed (especially on the plateau



OOPALPAD PLATEAU
Ea ten portn

END OF SMALL RAVINE
shewing mode of weathering

above and west of Owk) in east-west and north-south directions, but mainly east-west, and this may account for the quicker denudation; but it is hard to conceive how the great mass could have been so cleanly removed from such extensive surfaces of the thinner and less hard underlying beds without an equally advancing destruction of these. It seems preferable to look on this absence of pinnacled beds from the terraces as being mainly due to their having thinned out over them, and probably never having existed at all on the further outlying flat-topped hills which are only capped with the lower beds. On the other hand, it is worthy of notice that the flat-topped hills north-west of Banaganpilly are many of them only capped with pinnacled beds, while the more easterly of these have caps of the lower beds. This last ties in with the thinning-out of the group at Kypaw, and for some distance north of that village.

Denudation and weathering of pinnacled beds.

The peculiar manner in which the pinnacled beds have been denuded and weathered is very well seen in many places all over the field of these rocks, but best where there is a good superficial show. The slopes of all the hills about the area of the Paneum dome are strewn with more or less cubical masses of the fallen quartzites of every size, up to huge fragments of 20 to 40 feet cube, which have become detached from the scarp, and have either remained resting on the slopes or lie scattered about over the plains below. The three views here given, Plates II and III, are partly illustrative of the block-strewn slopes of most of the hills north-west of Banaganpilly, &c. The sketch No. 1, (Pl. II), embracing, as it does, a good part of the eastern half of the Oopalpád plateau, only shows the strewn blocks very minutely. Along the scarps where this member of the group is alone developed, and the denuding forces have cut well down into the underlying shales and limestones, the buttressed and pinnacled form of weathering does not show so well. Under such circumstances, the great buttresses of rock have generally become detached, and there is very little of clear

cutting back for any depth into ravines among the quartzites themselves. In cases where there is a good superficial display, as on most of the plateau, the surface for some depth is worn into ravines, or great spreads of rock have been cleared away, (Plate II, Fig. 2; III, Fig. 1), leaving lines of low vertical cliffs with fringes of pinnacled and buttressed masses of rock, almost exactly, on a small scale, like an iron-bound coast of a shallow sea from which the waters had retired. It requires very little imaginative power to picture the water swirling and eddying among the great outstanding masses of rock below the cliffs on which the spectator might take his stand. Plate III, 2 gives a rough sketch of one of these lines of fringed cliffs from the Kortycoonta plateau above Ramulcottah.

The most striking example of this mode of weathering is to be seen on the road from Kurnool to Nundyall in the Poolcherla plateau. The isolated masses of horizontally bedded quartzite occasionally stand up out of the flat plain of cotton soil alongside the high-road, as they might out of a spread of water; while the road runs for some distance (as it crosses a low part of the plateau) below a line of low cliffs with its fringe of quaintly weathered masses of rock, some of which are worn into seemingly castellated groups. It is not an unusual thing to hear people who had travelled along this road in the day-light remark how much they were struck with this strange resemblance to an old coast line. The same features may be seen, though not to so large an extent, nearer to Paneum, as the road passes out of the Tumrazpilly valley; and, by the way, this very valley is strewn all over the slopes of its steeply scarped sides with some of the largest masses of the detached pinnacled beds. The Oopalpád plateau shows very frequent examples of the fringed cliffs, particularly upon its northern slopes; and there is the very picturesque ravine of the Owk river which is worn deeply back nearly right across the plateau, with its lofty vertical sides and bed filled up with the great masses of the quartzites which

Fig. 1 Ravine cut back in the Pinnacled quartzites.

Fig. 2. Line of cliffs from Korty coonta plateau above Ramulcottah.

have fallen down. The following sketch is of part of one of the lines of cliffs at the entrance of a shallow ravine west-south-west of Paneum, the height of the tallest mass being about 40 feet:

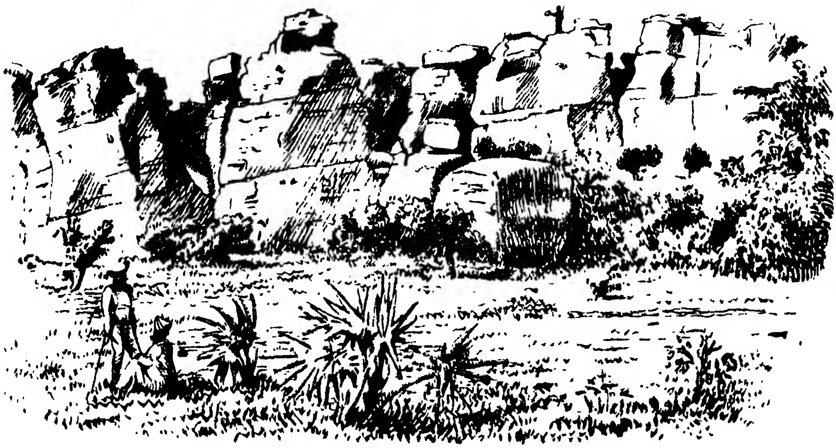


Fig. 7. Cliffs of pinnacled quartzites near Paneum.

Bent-over strata of scarps.

Though the pinnacled beds, and indeed the whole group, generally lie horizontally, or nearly so, there is very often round the scarps an apparent rolling down or bending over of the beds. This is mainly, and probably altogether, due to the washing out or crumbling away of a series of very soft shales which immediately underlies them. As the denudation or weathering has gone on, these shales have been partly crushed out by the superincumbent weight of the thick quartzite beds, and partly carried away, when the cropping edge of the beds of course sunk forward, and finally rolled down the slope. It is worthy of remark that this bent overlie of the edging beds is more peculiarly characteristic of the pinnacled beds, as is also the more overhanging scarp. With the lower beds there is some tumbled scarp occasionally, but, as a general rule, one steps down directly on to the slope of the shales, which cannot always so easily be done if the scarp be of pinnacled beds.

Mode of weathering similar in other quartzite.

While describing this occurrence of tumbled masses of white quartzite strewing the slopes of the hills capped by this rock, it is necessary to warn the observer against concluding that certain other tumbled fragments of quartzite which strew the slopes of a range of flat-topped hills in the Cuddapah district, between the Paupugnee and Chittravutty rivers west of the Gundycotta range of hills, are of this group. These last are of quite a different group of quartzites to be described hereafter, and it is not difficult to distinguish them. The fragments of the pinnacled beds are nearly always more or less white in color, and very nearly cubical in form, that is, they are of a good thickness as compared with their length and breadth. The fallen fragments* to be distinguished from these are of coarse grits and sandstones (quartzite) of dark colors, and more tabular in form than the *Paneum* fragments.

We have not been able to recognize anything of organic structure in this group: the pinnacled beds occasionally show a rather curious concretionary structure of a globular shape, but these bodies are all made up of sand. The beds show frequent examples of ripplings, particularly the plateau quartzites.

Thinning out.

It has already been related how the quartzites of this group have thinned out at Kypaw; but there is clearer evidence than this of their having died out altogether along the eastern side of the Khoond-air valley, where there is not a single instance of outcrop from under the *Khoond-air* limestones in any of the sections exposed; the shales that are found lying underneath the quartzites of Banaganpilly hills, &c., appearing directly under the *Khoond-airs*. The Kypaw section is a very interesting one; it is most difficult to find out where the rest of the quartzites, which

* In the locality where they occur the people of the Cuddapah district liken these tabular masses to troops of frogs ascending the hill sides, and have built up a legend on the resemblance.

must have sunk down into the plains (if they were still continuous for any distance eastward,) would be likely to appear south of Cherlopully tank, considering that the country to the south is a great plain mostly covered with cotton soil, and therefore very unlikely to give any outcrop of rocks. The beds of quartzite up to Cherlopully tank are rather obscure, but still they show evident signs of thinning out, and when, after traversing the country many times, the Kypaw section was found, this became quite evident. Here the *Paneum* group has dwindled down to a ten-feet band of sandy shales apparently shading down to the white shales next to be described, over which is a six to eight-inch bed of sandstone quartzite. There are limestones immediately above, and the shales below soon change into calcareous flags. Here the pinnacled beds have completely disappeared or died out. Southwards of this point there was no more evidence of this group of quartzites, though it is quite possible that it exists, for the country is almost totally obscured by soils.

'Wall' of quartzites.

The PANEUMS also die out to the north some distance beyond the Oondootla plateau, but before doing so they sink down from the Oondootla flanks below the limestone plains, by a sharp curve which Mr. Foote has called the quartzite 'wall,' and to which he refers as follows:—

Mr. Foote's notes.

"The most interesting and remarkable feature in the position of the quartzites is the singularly long and narrow wall joining the north end of the Oondootla plateau with that of Chintalpilly. This narrow wall of rock owes its existence to the action of the two opposite forces of upheaval and denudation. By the first a large area was elevated, forming the whole of what has been described as the Oondootla and Chintalpilly plateau and the intervening space, the northern and central parts of the elevated region, was removed by the denuding force, thus disclosing a considerable tract of the underlying rocks which chiefly belong to the older or lower series of the newer metamorphic rocks, the KADAPAH ROCKS. This remarkable wall of quartzite corresponds with a line of fault, but there has been apparently little or no dislocation of the strata on either side of the fracture. The action of the denuding forces, however, has been unequal, and the various outliers of pinnacled quartzite and the underlying strata, limestones and diamond-quartzites, render the

geology of the area of denudation south of the wall most interesting and rather complicated. Of the pinnacled quartzite only two outliers remain, one about two and a half miles east of the large village of Calwa; it is of small extent only, but important and conspicuous, because perched on the top of a short flat-topped ridge rising nearly 300 feet above the valley. The top is capped with the quartzites, and distinguished by several fine specimens of pinnacle 'tors'. This capping rests upon a great thickness of "Owk shales," and the east end of the ridge offers a capital section of these underlying rocks. This small outlier at once explains the formation of the quartzite wall. The wall, for that is the best name descriptive of the long narrow line of outcrop of the quartzite, measures about 13 miles from Chennagapilly, westward to its junction with the Chintalpilly plateau. Throughout this whole distance it retains its character of an independent ridge wall, except for about half a mile along the base of the Goomanconda, where it leans against the hill.

"The northward dip of this great basset edge or outcrop is generally very high indeed, varying from 60° to 80°. Except in one place a little south-west of Calwa the top of the ridge is extremely narrow, often not more than 20 to 30 feet. But near Calwa the bed makes a double dip, as shown below in section, owing to less complete

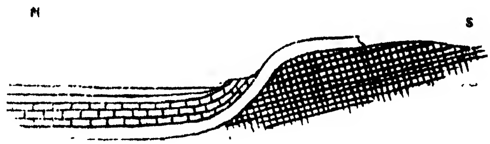


Fig. 8. Sketch-section near Calwa.

denudation for a distance of three or four hundred yards, to the south of Bapunpilly, where the wall-like character of the quartzite outcrop is extremely well developed; this bed rises in cliffs, but little short of a hundred feet high above the valley of the Khoond-air. At foot of the quartzite wall, the Koilkoontla limestone appears in very many places dipping north at an equally high angle; but as it is followed in to the plain the dip rapidly decreases, and before it crosses the bed of the Khoond-air, the beds approach very nearly to horizontality. The quartzite is throughout the length of the outcrop very white in color, and differs only from the less disturbed portions of the formation in being less distinctly laminar,—a change of character which may have been brought about by the enormous pressure and consequent heat during the process of dislocation at that very part of the originally undisturbed bed. The mass of the rock in the wall is much more broken up by irregular fissures than where inclined at a low angle."

Chapter 3.—The Jummulmudgoo group.

The group of quartzites just described is found to rest quite conformably on a set of finely laminated buff shales which in their turn merge downwards into a thick series of limestones; but the quartzites are not co-extensive with the shales, while the latter are, so far as is known, always associated with the limestones beneath. There is no reason why the shales should be separated from these lower beds, and there is thus a second limestone group in the karnúl formation which may be called the

The *Paneums* rest on a set of shales with subjacent limestones.

JUMMULMUDGOO GROUP

and which may be described as consisting of two members, the uppermost of which is called after the large village of Owk in the Koilkoontla taluq,

The Owk Shales.

These shales are, in all cases, non-calcareous, that is, they do not effervesce on being touched with dilute nitric acid: and in this they are to be distinguished, in case of an agreement in color, from the Nundial shales of the upper limestone group which are so distinctly calcareous. They are typically of white and buff colors, shading occasionally by reds into purples and browns and are very fine-grained and well laminated. Unweathered specimens are hard and compact, often almost like chert, or like biscuit-ware; but the rock is for the most part weathered and consequently soft and crumbly. In the southern part of their area they become somewhat sandy and coarse in the upper strata, or earthy and calcareous as the limestones beneath them are approached, gradually changing without any well-defined separation into grey flags and so down to the true limestones. In the latter case, though it is so difficult when one is among the rocks themselves to distinguish any

Owk shales and their character.

definite division between the limestones and the shales, yet from a distance there is a most decided appearance of division in the group into the two bands, shales, and limestones; this feature may be well seen on the upper slopes of any of the outlying flat-topped hills of the Koilkoontla taluq, as shown in some of the sketches we give.

In the middle of the field of KARNÚL rocks, as among the Banaganpilly hills, the buff shales are immediately under the massive quartzites of the pinnacled beds with scarcely any intermediate layers of sandy material. They are mostly well-marked buff and white, finely laminated and (unweathered) hard shales. Along the inner western scarps of the hills south by east of Kurnool, the shales are seen more distinctly between the pinnacled beds and the underlying limestones, and there is rather a sudden change from finely laminated shales to limestone beds. This decided character of these rocks as a clear band between the *Paneums* and the limestones is very evident all round the scarped edges of the ranges of hills and plateaus between Banaganpilly, Kurnool, and the Khoond-air valley, and they are tolerably constant in their white and buff colors. In the Oondootla plateau, towards its north-east extremity, the rock occurs as a soft, fine, and gritty shale of a buff color, and is not unlike the 'bath brick' of commerce. In the Poolcherla plateau (north-west of Oondootla) which is of pinnacled beds, the underlying Owk shales show typically as a thin seam in the western scarps, and they sink down at the north-north-east extremity of the ridge with the quartzites, and so become to a certain extent lost under the cotton-soil which is so prevalent here. They, however, show again at intervals up to Nundycotecoor, but without any trace of the overlying quartzites.

Imitations of organisms.

The Owk shales are nearly all over the field so beautifully laminated and so recent-looking that it becomes a matter of wonder how there are no evidences of organic life displayed in them; such is, however, the case. At least, after repeated searches among them, we have always failed to find any fossils

or traces of such. As in the case of the limestone flags, however, the observer may have his curiosity whetted by finding occasional assemblages of exceedingly thin discoid bodies of about a sixteenth or an eighth of an inch in diameter, and generally of a dark brown color spread out on the surfaces of some of the laminæ. These are somewhat like cycloid scales of fish; but no organic structure has been recognized in them. There are also frequent layers of small pisolitic concretions scattered through the more compact grey and purple shales.

Extent of shales.

The lateral extent of the Owk shales is much greater than that of the overlying quartzite group, for their outcrop is seen showing up from between the Koilkoontlas and their own associated limestone beds, along the southern half of the eastern side of the Khoond-air valley; there never being in any exposed section the least trace of quartzites of any kind except those of the bottom of the KARNÚL and of the KADAPAH formations.

50 feet of Owk shales.

The greatest thickness known of these shales is about 50 feet, that is of the buff, white, and purplish beds. There are from 20 to 30 feet in the hills above and behind the village of Owk* (whence the name of the sub-division is derived); 30 to 40 feet in the south-west scarp of the Oopalpâd plateau; 40 feet on the eastern slope of the long outlying flat-topped hill due south of Oopalpâd; 30 feet in Colimgoondla hill,† and 40 to 50 feet in the most southerly of the other flat-topped hills south of Koilkoontla.

Cleaved.

In the outcrop of the shales along the eastern side of the Khoond-air valley, it is seen that they are cleaved in the same way as is the case with the Nundials, only this feature is not so well exposed as in the upper shales; neither does it appear that they are so well cleaved. The Nundial shales are, as already shown, very much cleaved, almost to the obliteration of bedding in

* Owk is a large village in the Koilkoontla taluq, Kurnool district, on the extreme western edge of the Khoond valley. 15° 12′ 30″ N. Lat. and 78° 10′ 30″ E. Long.

† Colimgoondla hill, pagoda-crowned,—about nine miles due south of Owk.

places; and the limestones below them are so changed that for a long time they seemed to belong more properly to the group next to be described, only that sections were continually found, which cleared this obscurity up. Still the Koilkoontlas are not so much cleaved as the lower limestone beds, so that the cleavage has not been so evenly distributed through the groups as might have been expected, a feature which probably depended more on the constitution of the rocks than anything else.

The planes of cleavage among these rocks on this side of the valley run nearly due north and south with a dip of 60° eastward.

The Nerjee limestones.

Nerjee limestones.

Beneath the Owk shales come the thick series of Nerjee limestones.

This name has been adopted* more particularly because the rock is becoming generally known over the district, particularly along the north-west line of Railway, as the Nerjee Stone, from the fact of large quarries† having been opened in it at the small village of Nerjee in the Cuddapah district. There are many other villages of greater importance where the rock is even more extensively developed, but the name Nerjee Stone is very likely to spread largely over the country, when the stone can be brought within reach of places where building is going on to any extent.

Their character.

The Nerjee limestones are typically very compact, sub-crystalline, and extremely fine-grained, so much so that it is from these beds that the so-called lithographic lime-

* The term 'Coralloid Limestone' was suggested by Mr. Foote on account of the mode in which the more compact beds are weathered. The exposed surfaces of the strata often present a remarkable resemblance to some forms of coral, owing mainly to the presence of exceedingly thin seams of silicious matter in the planes of lamination. However, the same style of weathering is common in the more compact and crystalline varieties of the Koilkoontlas; so that an ambiguity might arise in the use of Mr. Foote's term.—W. K.

† These rich limestone quarries were opened and are being very largely worked by my friend Mr. E. W. Barnett, contractor on the Madras Railway, and the stone is now being imported to Madras for building purposes. The new building for the Madras University is partly constructed of it.—W. K.

stone of the Madras Presidency has in some cases been obtained. It is generally of a grey color with a blue shade, sometimes nearly black and occasionally of pale buff and fawn colors. The whole series of these limestones properly consists of several bands differing as to thickness of beds, color, and constitution. The band of grey and blue beds is constant, and distinguishable throughout the whole field; and these may be considered as typical rocks of the series. The non-compact and crystalline varieties are rather silicious in their composition, the silica being evenly distributed through the rock in most instances; and in others distributed apparently in exceedingly thin layers. The blue beds are the most crystalline and compact, ringing out when struck with the hammer, and breaking with a conchoidal fracture. They weather with surfaces resembling certain corals.* The grey beds are often as compact, but they run into flags and earthy beds, while the more compact varieties are even more coralloid in their weathering than the blue beds. The darker and nearly black varieties are very compact and not so splintery

* Mr. Foote, who at the time was strongly in favor of the organic structure of this variety of the *Jummulmudgoo* limestones, writes as follows with regard to the beds at the north-east end of the valley on the northern flank of the Oondootla plateau:—

" The surface of the weathered rocks assumes a coralloid structure due to the presence of films of silicious matter scattered through the rock and presenting patterns of such a character that it is difficult to ascribe them to any but organic causes. These quasi-organic structures are of three kinds. The most organic looking of the three presents the appearance of circular pores from $\frac{1}{10}$ to $\frac{1}{4}$ of an inch in diameter, formed in the thin film of silicious (?) matter which rises slightly above the general surface, just around the edge of the pore.

" The film is punctured by these pores at irregular distances from $\frac{1}{8}$ to $\frac{1}{3}$ of an inch apart from each other on the average, but not forming any particular pattern among themselves. The distribution of the circular pores is in pattern, or rather want of pattern, analogous to the exhalant apertures of a sponge. The film which is rarely more than $\frac{1}{20}$ of an inch thick, and generally less, is of greyish yellow or pale greyish brown color and of generally dull lustre or altogether without lustre, and lies nearly in the same plane as the true laminæ of deposition. It cannot be traced in the interior of the freshly fractured limestone; but as the limestone has been neither tested with acids or submitted to microscopical examination, it is impossible to decide as yet whether these films be really organic or inorganic structures actually contained in the substance of the rock, or whether they be only pseudo-organic modifications of the surface induced by some chemical action during the process of weathering from exposure to atmospheric influences.

as those just described; and they are the best building material in the whole series. The fawn-colored and buff beds are extremely compact, very fine-grained and very splintery, breaking off with edges as sharp as a knife.

A triple banded series.

It is very seldom that all these varieties are found in one section, for the bands thin out and disappear in different parts of the field; but if such a complete series could be found it would show that the earthy grey beds are uppermost; that the compact black, blue, and grey beds are about a middle band, with the base of which the splintery varieties are associated; and that lowest of all comes a further set of grey beds, which are, however, different from the upper greys in that they are hard, compact, and splintery like the blue beds, and contain purple beds with segregations of dark purple chert in odd-shaped strings, knots, and laminæ. This is about the general succession all over the field.

"The second of these three structures is yet more enigmatical in character and appearances, and somewhat less strikingly like an organic body in its general aspect than the foregoing.

"It may be compared in appearance to a very much weathered specimen of a fungoid coral having the large vertical plates very far apart and showing no minute cellular structure. The vertical plates generally radiate from a clear but slightly depressed space of either circular or elongated elliptical shape, according to the distribution of the plates. The plates very rarely meet at the apical space in the circular, or across the centrically depressed ridge in the elongated, examples where these are best developed.

"The spaces between the vertical plates are occupied by limestone which is generally weathered down to a level of from $\frac{1}{4}$ to $\frac{3}{8}$ of an inch below the ridges formed by the plates in large specimens. The lateral distance between the plates at the apex or summit ridge is very variable, but is generally less than $\frac{1}{2}$ an inch; and the divergence in the circular specimens is necessarily larger than in the elongated forms.

"The third form alluded to is, in structure, a substance intermediate to the first two, having the delicacy of the first in great measure and an approach to the vertical arrangement of the plates of silicious matter along the outer margin of the area covered with the perforated film. In this kind, the central part is, as a rule, elevated an inch or $1\frac{1}{2}$ inch above the plane to which the furthest and lowest ends of the vertical fringing plates may extend.

"These quasi-organic bodies were not observed in any of the older or younger limestones of these newer metamorphic groups of rocks." As I have written above, I have since seen the coralloid form of weathering in the Koilkoontla Limestones.—W. K.

The three following sections are illustrative of the order of the different limestone bands.

North of Ramwarum village there is this general section in descending order:—

Jummulmudgoo group.	Owk Shales.	
	Nerjee Limestone.	Grey calcareous flags (under Owk shales).
		Thicker beds of compact dark grey and nearly black limestone.
		Pale-grey and whitish thin-bedded compact limestone.
		Grey flaggy limestone, or calcareous flags.
		Thick beds of grey and purple silicious limestone with irregular chert segregations.
		Grey laminated sandy shales.

Banaganpilly Group. 20 feet.

Again, in descending from Ramwarum Conda on the eastern side:—

Paneum Group. 30 feet.

Jummulmudgoo Group.	Owk shales.	70 feet.	Owk shales with flags at the bottom.
	Nerjee Limestone.	50 „	Compact dark limestone.
		30 „	Compact white and grey limestone.
		50 „	Limestone flags.
		50 „	Silicious limestone, with purple segregated cherty beds.

In crossing the 'wall ridge'* of the north-west flank of the Oondootla plateau from Chennaganpilly, the following section occurs:—

Paneum Group (in this case the 'wall-ridge').

Jummulmudgoo group.	Owk shales.		Owk shales, (wanting or squeezed out).
	Nerjee beds	30 feet.	Thin-bedded and flaggy grey earthy limestone.
		30-40 „	Thicker-bedded, compact, fine-grained, splintery blue-grey limestone. ('Coralloid'.)
		50 „	Thin beds of the above, grey color; pinkish and fawn-colored beds of limestone; very fine and compact, with ferruginous nodules. ('Coralloid'.)
		50 „	Irregular beds of limestone of a slightly 'coralloid' character; and thick beds stringed with purple chert.

Here, the Owk shales have either been squeezed out in the sharp twist which the beds have received in this 'wall-ridge', or they were never deposited in this part of the field; they show, however, further to the west.

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* See extract from Mr. Foote's notes pp. 65—66.

It is moreover found where the formation is thick enough, that beneath the purple chert segregated beds—except along what appear to have been the northern shores of this limestone sea,—there is a lower band of grey limestones with which are associated thin beds of sandstone and grit-quartzite which sometimes shade down by red and purple sandy shales to the next lower group of decided quartzites which are to be treated of in the following chapter. In the middle of the Koilkoontla limestone area on all the western bases of the inner western hills, north-west of Banaganpilly, these intercalated or associated grits are not of much importance as regards their thickness or extent; but to the south or south-west of the Oopalpád plateau, there is a very decided though thin series of two quartzites lying in the lower division of the limestone, and separated from the next succeeding lower group of quartzites by a band of limestone. At the same time this intercalated set of quartzites is of a lenticular shape, and thins out so much before the western scarp of KARNÚL rocks is reached in this region that it is not seen in the scarp. This low vertical edge of the KARNÚLS only shows a set of limestones with a seam of breccia overlying the lower group of quartzites.

Intercalated sandstones, &c.

The rock of this intercalated band is peculiar in being a sandstone and grit-quartzite, and is in some beds partly made up of felspar in a crystalline state; except for the peculiar lustre of the felspathic element, the freshly broken rock is to the eye an uniformly coarse-grained sandstone or quartzite of a brown color. On weathered surfaces, the rock is pitted with shallow and narrow cavities, of an inch or less in length, in shape like the section of a flat convex lens: and these lenticular cavities are irregularly scattered over the surface of the rock, or, as is often the case, two cavities meet with their ends at an angle; or they occasionally cross each other and give a rude representation of a star. Freshly broken surfaces then show these lenticular bodies on a cross light, when a peculiar adamantine lustre is

Character of.

seen. The rock is likewise made up, to a large extent, of the same mineral as are the lenticular bodies contained in it, thus giving even the general surface locally an adamantine lustre. It is so strong at times and so like the lustre of corundum that it at first resembles a sandstone partly made up of emery, which would have thus given a fine rubbing or polishing material; but subsequent examination showed that the mineral is felspar.*

This lenticular patch of quartzite occurs on the flat and scarped terrace above and to the east by north of Taudapurtee† (Bellary District) in the neighbourhood of the village of Oorchintala. It occurs apparently as a patch on the limestone of the terrace, but on working over the adjacent country one soon sees that it is intercalated among the limestone by the fact of its being also overlaid by the Nerjee beds. It is overlaid by the limestones of the capping of the headland just south of the village of Oorchintala, and about a couple of miles north of this village there is a low scarp over which the stream falls into a ravine, in which those quartzites are overlying the thin-bedded grey limestones which come under the blue beds.

The thickest part of these intercalated quartzites cannot now be more than 40 feet; and they occupy an area of some seven or eight square miles.

40 feet of intercalated quartzites.

It is unfortunate that these die out to the north, for they thus cannot be connected with those thin bands of quartzite occurring at the western bases of the Banaganpilly hills; but they certainly seem all to belong to one period of deposition, for they occupy as nearly as possible the same horizon among the limestones. The felspathic characters are not observable among these beds to the north-west of Banaganpilly.

* On examination with a magnifier, the lenticular assemblages of matter are found to be made up of coarse rounded grains of white quartz in a glassy crystalline matrix of felspar.

† On the right bank of the Penn-air; north-east corner of sheet 59 of the Indian Atlas.

Limestone-breccia.

A very peculiar bed or group of beds of limestone-breccia occurs in many parts (more particularly and distinctly to the southward) of the field close to the bottom of the Nerjee beds. This is a grey, purple, or greenish limestone, very compact and sub-crystalline; but made up of a closely packed agglomeration of fragments of limestone (to all appearance just the same as that of the enclosing rock) which are rather oddly shaped. The fragments look like pieces of what was a thin-bedded limestone: they are long and thin and somewhat rounded, though at the same time showing often sharply broken edges. They are confusedly jumbled together, not arranged in any order: and the rock looks more like a bed fractured and re-cemented *in situ*, though it is inconceivable how such fracturing can have taken place without its having affected in some way or other at least the beds below; some of the specimens of rock look more like a veined limestone, but the unmistakably brecciated character is very soon seen in other parts of the seam. At one time the rock is uniformly very fine-grained, compact, and splintery, of a reddish-brown color, in which the fragments of which it is made up are easily recognizable. These are arranged together most closely, but quite irregularly, with only the thinnest walls of calcareous matter, of a lighter color than the rest of the rock, between the pieces. The thin walls are of calc-spar in minute crystals. There are necessarily some interspaces between the ends of the enclosed fragments, and these are filled up with compact limestone exactly like that of the fragments. In other cases the true brecciated character of the rock is not clearly seen: for the interspaces, though filled to a great extent with the same material as that of the fragments, or with calc-spar, are thinly charged with minute rounded fragments of quartz in various colors, in fact with sand. Such is more particularly the character of this seam to the north, about the left bank of the Kistnah; but further south, along the western scarps of the terrace below the Oopalpád plateau,

it becomes more varied in constitution and in the character of its contained debris, being somewhat silicious and full of fragments of chert of various kinds as well as of limestone. It is still, down here, a distinct band of one or three beds of limestone breccia, the enclosed fragments being likewise of the same shape as those above described. I must confess that I am thoroughly at a loss to account for this strangely constituted band; for it is uniformly under and over-laid by beds of homogeneous limestones and calcareous flags. The included fragments cannot surely have been obtained from the beds immediately under it without having left an irregular and well denuded surface beneath, of which there is scarcely any trace; and if it be not a rock fractured and re-cemented *in situ*, the origin of its contained fragments must only be looked for from some other older limestones. There is a great group of limestones in the KADAPAH formation on which these are lying; it crops up to the westward, at from 10° to 30°, in a broad band which skirts the Oopalpád plateau at some miles distant in that direction.

There is certainly some trace of a period of time having elapsed prior to the deposition of the band of breccia on the lower beds, for the upper surface of these appears to have been worn slightly into shallow furrows, but this is by no means so clear as one could wish. This apparently worn surface may be seen occasionally along the face of the scarps above the village of Cona Oopalpád,* on the west side. Here it is nearly down on the surface of the older group of quartzites; only separated from it by a thin band of grey limestone flags.

In the northern part of the field, on the left bank of the Kistnah river, however, it is at times the shore-bed of the *Jummulmudgoo*

* Cona Oopalpád must be distinguished from Oopalpád: the latter village is on the plateau of that name in the south-east corner of sheet 58 of the Indian Atlas, 15° 10′ North Lat., 78° 6′ 30″ East Long. Cona Oopalpád is down in a low valley ten miles and a half to the west-south-west.

group, and so more likely to be a true breccia with interspaces full of sand. The subsequent alteration which these KARNÚL rocks underwent must, of course, have affected the character of the limestones to a certain extent, and the obscurity of the brecciated character of these beds in certain places may possibly be owing to this alteration.

Nerjee beds at Kurnool.

In the part of the Raichoor Doab*, about the town of Kurnool and its neighbourhood, the proper Nerjee limestones themselves (irrespective of the brecciated band) have become distinct shore-beds as they thin out over the grits of the next lower, or Banaganpilly, group, or even as they have overlapped these and lie directly on the gneissic rocks, or their granites. In such cases the limestones at times are very jaspery, or rather cherty, and segregated and brecciated in a peculiar manner. In no case are they penetrated by any igneous rocks, but they are certainly altered (or baked) and squeezed or crushed up locally. There is a very good example of this in the town of Kurnool near the powder-magazine (bastion of the fort): where the hitherto horizontal limestones a short distance west of the bastion, are bent up almost vertically in a line running from the bastion south-south-west to the village of Culloor, and are seamed with calcareous chert, jaspers, and silicious incrustations in the most marked way. The limestones here are very silicious, and they are lying directly on rather peculiar rocks of the older crystallines which may possibly have been igneous themselves. It would then appear that when these limestones were being deposited along the shore, or at any rate not far from the shore of that period, that debris of the older quartzite beds (Banaganpilly beds) and of the gneissic and granitic rocks became washed into and incorporated with the lower strata of the rock; and that the diverse composition of the beds gave cause for partial segregation, during metamorphism, into the peculiar forms

* The Raichoor Doab is the eastern part of the country between the Kistnah and Toongabudra.

which we see now. It is not at all improbable either that some of the limestone beds, even after their having become hard, permitted of sand being washed into their crevices of fracture and were subsequently altered until the rock ran together again in one uniform mass.

Shore-beds: Mr. Foote's notes.

Mr. Foote more particularly examined these shore-beds and refers to them in his progress reports as follows :—

" On the banks of the Toongabudra below Kurnool, the section in which the contact of the *Jummulmudgoo* limestones with the older metamorphic rocks is best seen occurs at Shaitancottah (Chatumcottah of map) on the right bank of the river about five miles above the confluence with the Kistnah."

" The very bottom laminæ of the limestone contain numerous small chert pebbles; and in a few small patches the limestone has almost disappeared, being replaced by a pebbly quartzite. The limestone follows all the inequalities of the gneiss surface, and adheres with considerable tenacity. The beds have a slight dip to the east. To the east of the village, the limestone forms a low but picturesque line of cliffs along the south bank of the river; and in several of the gullies are small examples of ' swallow holes.' There is a rather remarkable bed of quartz, chert, and jasper gravel covering the limestone surface for a considerable distance inland from the edge of the cliffs and extending for about a mile eastward from the village of Shaitancottah."

" The contact of the limestone with coarse syenite is also to be seen in the bed of the Toongabudra, when not in flood, on the right bank opposite to Alumpoor. The limestone dips at a low angle towards the town."

" Close to the Kistnah the juxtaposition of the granitic rocks of the Doab with the limestone is well seen at the village of Chundoor, near the embouchure of a large nullah which flows into the Kistnah. The limestone is seen resting on the granite, which is here traversed by a dyke of purplish green trap, which for a distance of several hundred yards directly underlies the outcrop of the limestone. The base of the limestone is not pebbly in this section, but there is an abundance of jasper in it in the shape of strings and concretionary lumps, many of the cavities in the jaspery parts of the rock being lined with minutely mammillated botryoidal reddish chalcedony. Many very fine specimens of red and white (chalcedonic) jasper are here procurable. Where most jaspery, the limestone is of greenish blue or purple color. A foot or two above the line of contact the limestone is of dark or moderately dark-blue color, and is a fine compact building stone; very extensively developed in a south-east and south direction, especially at Murramoongaul and Paugtoor. Where the limestone rests on the trap dyke above mentioned a singular breccia has been formed by the infiltration of calcareous and silicious matter through the innumerable small joint-fissures

by which the trap is traversed. This infiltration has not descended deeper than from 4 to 5 feet below the point of contact with the limestone bed, as may be seen by the section in the bank of the Chundoor nullah. Where the spaces between the trap masses are a little wider than usual, a tendency to the formation of *geodes* may be observed,—and imperfect very irregularly shaped *geodes* may be occasionally found, the quartz crystals lining the cavity being generally of dull white, and the intervening space, if there be any, is filled up with calcite. This highly jaspery character of the base of the limestone continues southward and south-westward from Chundoor to near Jullapoor. About three quarters of a mile south of Chundoor the same process of infiltration into the spaces between the blocks composing the broken surface of the granite itself is very clearly exposed. Many considerable blocks of the coarse reddish granite are supported on and enclosed by the limestone, forming an immensely coarse conglomerate. There can be little, if any doubt, but that these blocks were originally enclosed when the soft calcareous mud was first deposited on the broken surface of the granite; and that both here and at the Chundoor trap-dyke, the process of infiltration was contemporaneous with the original formation of the limestone beds. In all the large spaces between both the granite and trap blocks, the limestone or silicious matter occupying them, is undistinguishable from the parent mass above.

"At Jullapoor, the base of the limestone becomes a breccia with included angular fragments of granite.

"Another and much finer example of a (filtration-) 'breccia' formed by the inclusion of blocks of syenite and granite composing the broken surface on which the limestone was deposited, is to be seen on the north side of the Kistnah a little distance west of the telegraph towers in the river. The bed appears to be 8 to 10 feet thick. The limestone between the blocks is highly charged with jasper, and generally purple in color. A little further still to the west are several spots at which the limestone has been almost entirely removed, only films being left here and there in slight depressions in the syenite surface, the light blue or slightly purple limestones contrasting strongly with the pale syenite and reminding one forcibly of small pools left behind on rocks by the ebb tide, or by a heavy shower of rain.

Evidence of Kistnah valley being older than KARNÚLS.

"The valley of the Kistnah near Veapurla (the ford at which the Kurnool–Secunderabad road crosses), appears to have followed for a few miles the direction of a slight synclinal fold in the limestone, the base of which has been almost entirely eroded by the action of the river. Confirmatory of this view is not alone the decided northward dip of the limestone beds between Murramoongaul and Chundoor, and the rather less southerly dip of Veapurla limestone beds, but also the presence in the bed of the Kistnah at the mouth of the Chundoor nullah, about a hundred yards from the bank, of a small strip of the limestone *in situ* in a depression in the granite. The position of this with regard to the much higher level occupied by the limestone on either side shows that there must have been a synclinal fold at that point with a strike from north-west to south-east."

The intercalation of quartzite, and cherty and brecciated seams of limestone among the lowest beds of the *Jummulmudgoo* group, is very confusing, particularly as there is no continuous outcrop of the lowest beds for any distance. For instance, the most continuous outcrop of the lowest beds of the Nerjee rocks shows no passage from their bottom beds into the quartzites below, except by a few sandy calcareous shales occasionally: throughout some miles of scarped outcrop of nearly horizontal beds, there are limestones lying directly on sandstone-quartzites with only a few thin beds of calcareous and earthy flags and shales. And then we have in the other cases just related, the intercalations of a patch of quartzite, or of thin beds of this rock.

Indefinite position of quartzites and breccia beds.

It is difficult thus to make out how the different bands of quartzite are lying with regard to each other; and whether they are above or below the brecciated band. From all that can be made out, the intercalated quartzites are very nearly on the same horizon with the red-purple chert-seamed limestones. This is the case in a long east-west valley cutting through the hills between Paneum and Boganpully. There is some approach to this, though with no decided bed of quartzites, on the Coondanacota terrace on the south side of the Oopalpád plateau below Boorgul; where, in passing over a good spread of the purple cherty limestone west-south-west of Coondanacota, traces of a half sandy set of beds come in. In working out the large patch of intercalated sandstones in the Oorchintala plateau further south, a northern extension of the little group distinctly shows along its eastern side, as coming in under the cherty beds.

The seam of breccia beds is below the quartzites, and wherever it occurs it is at or near the bottom of the group. There is rather a clear section displayed immediately east of the village of Goodypaud, also on the limestone terrace below the southern scarp of the Oopalpád

plateau. One approaches the village from the east, over flatly bedded blue limestones; compact, semi-crystalline, black and bluish-grey Nerjee stone. Then as the stream is followed to the village, this fine rock is gradually lost in a thin-bedded, grey, earthy limestone, below which are purple cherty beds. Immediately at the north-east corner of the village, there are two or three thin beds of compact fine-grained, dark-green and grey quartzites, under which comes a bed of chert-breccia, 6 or 8 inches thick. Below this, again, is a series of compact semi-silicious limestone on which the village is built; under these come about 20 feet of purple sandy and clayey shales, at the bottom of which are a bed or two of purple jaspery segregated limestones with sandy shaley partings. These rest on sandstone- and grit-quartzite of the Banaganpilly group:—

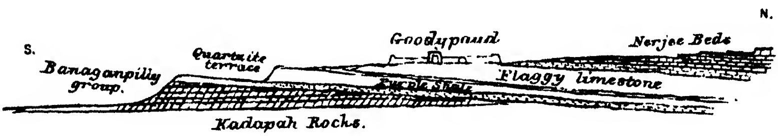


Fig. 9. Diagram section, through the village of Goodypaud, Kurnool district.

Unconformity of *Jummulmudgoos* on strata of Goondicottah hills.

So far then as the *Jummulmudgoos* have been examined, it is found that they lie consecutively on a group of quartzites, though some period of greater or lesser duration must have elapsed before the limestone group began to be deposited; for there are every now and then evidences of the upper surface of the quartzites having been denuded to some slight extent, before the sandy and calcareous shales and flags or limestones were formed over them.

There are, however, a couple of examples in which the limestones rested unconformably on a series of quartzites, which are not at first to be distinguished from those of the lower group. These are in the

southern part of the field, where indeed the most interesting denudation of the KARNÚL rocks seems to have gone on, and are just below the south-east corner of the Oopalpád plateau and its outlying flat-topped hills in the neighbourhood of the villages of Noyanpally and Pellnycota. Close by these villages, the 'blue beds' of the Nerjee limestones rest at once and unconformably on quartzites, and at the same time present the rather strange composition, for this particular band of limestones, of a calcareous grit, conglomerate, and pebble bed. At Noyanpally, just west of the village, are thick beds of the typical blue limestone in the stream-bank, weathering into coralloid forms. The bottom bed of these is a very coarse white calcareous sandstone, apparently enclosing fragments of the compacter limestone. This is, however, deceptive, the bed being irregularly seamed with white sand, which has assumed occasionally a rather tortuous and broken course in its deposition throughout the rock. These lower beds of limestone and calcareous grit lie unconformably up against an undulating set of quartzites.

Limestone grits and conglomerates.

To the west of Pellnycota, the Nerjee limestones are seen to be distinctly unconformable to these quartzites. They are lying horizontally over undulating beds, and in many places may be seen lapping round protruding knobs of quartzite with irregular bedding. The lowest beds of limestone are full of layers of small pebbles thickly gathered together; and these occasionally become a very coarse conglomerate of large, smooth, and round pebbles of quartzite with occasional large pebbles of trap. There is also a thin bottom bed (in another part of the boundary west of the village) of nothing else but small pebbly gravel in a matrix of limestone. At two or three points west-south-west of the village and close to the boundary between the limestones and quartzites, there are calcareous conglomerates of the most coarse character which are quite wonderful in the size and smoothness of the enclosed boulders of quartzite and occasionally of

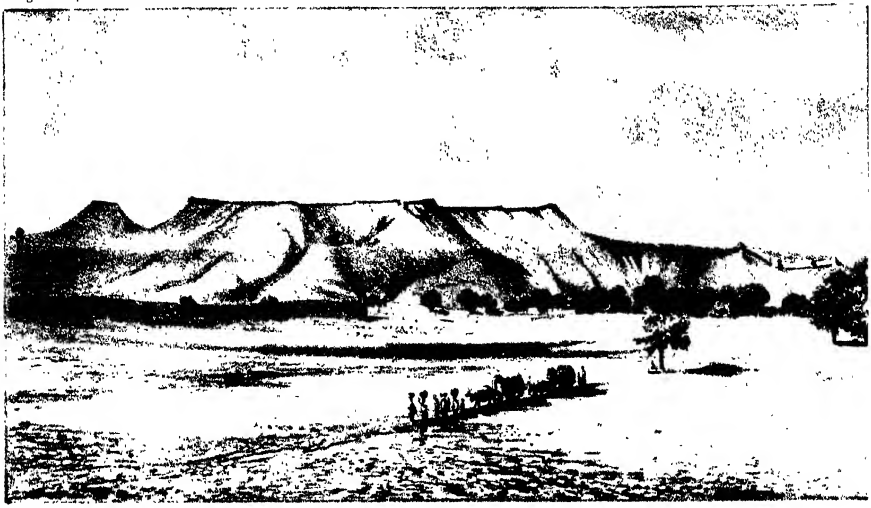
trap. This conglomerate varies very quickly, within a few yards, from an extremely coarse deposit to a fine pebble bed. All round the low hills south of Noyanpally the limestones may be seen lapping horizontally over the undulating quartzite strata of the hills themselves.

Again, still further south, and not far from the south-west scarp of the KARNÚL rocks, near the village of Moomoypully, are 'blue beds' overlying quartzites in a peculiar manner, with a sintery and jaspery calcareous breccia and conglomerate lying locally between the two series. Between the village and its tank to the south-west, there is a somewhat similar case to that of Pellnycota in an irregular low ridge or undulation of tumbled quartzite, either in beds or broken masses, about which the earliest deposition of the Koilkoontla blue beds was formed. Possibly the whole ridge may really only be made up of huge broken and tumbled fragments of quartzite; nevertheless the limestone is deposited in and out, and over these irregularly placed masses of quartzite beds, along courses of jointing, or between the blocks, or in hollows, as though there had been here an old sea-bottom, with a low reef of tumbled *debris* of large masses of quartzite in their various forms of fracture.

Here we have in both cases a decided unconformity, as well as overlap; while the covered quartzites are not of the next lower group, but of the much older KADAPAH rocks.

Denudation of this group.

The denudation to which the *Jummulmudgoo* group has been exposed is most wonderfully and picturesquely displayed about here, or in fact along this south-west boundary. The overlying quartzites must have protected the thick series of limestones for a long time and to a great extent, but in the end they had to yield to overpowering forces in this particular part of the country, and there are now left numerous flat-topped hills with steeper or gentler sloping sides, down the greater part of which one can descend as by steps, the stratification is so regular and nearly horizontal, to the deep valleys between, or scarped terraces of limestone below. These



OLLAVACONDAH.
Village and hill

J. Schaumburg Lith. W. King

NOYANPULLY
Village and hill

terraces of limestone, particularly to the south of the Oopalpád plateau, are of perfectly bare rock, with hardly a vestige of vegetation except where there may be an occasional patch of cotton soil. Most of the flat-topped hills about here are about 300 feet high, and the area over which they occur is fully 100 square miles, which may give an idea of the considerable amount of denudation which must have gone on, to clear away such a great amount of limestone beds as originally existed here. The accompanying views show the peculiar forms into which the hills have been worn, as also the depths to which the Koilkoontla beds have been denuded. The flanks, or sides of these plateaus, are, as a rule, well sloped; but there are instances, as below Ramwarum Conda in the Oopalpád plateau, when the harder and more compact beds of limestone are well developed, where the sides of the hill assume a more cliffy and vertical form; they are ornamented by occasional examples of fine buttresses and out-standing scarped masses of horizontally-bedded strata. Fig. 10 shows an example of this, in a wide and deep valley immediately south of Ramwarum Conda.

Pl. IV, Fig. 1, is a view of Ollavacondah, a fortified hill south-west of Koilkoontla; showing the peculiar form of the plateau-hills of this region, the banded character of the slopes, and the depth to which the *Jummulmudgoo* strata have been denuded. The lower dark band of the slopes is of earthy limestones and calcareous flags and shales, the upper and lighter of Owk shales, and the platform of the capping point is of *Paneum* beds.

The banded character of this group of rocks is, however, perhaps, nowhere better seen than on some of the terraces below the hills, when the spectator is looking down on them. This is most particularly the case in the western terraces below Noornabode hill (north-west of Banaganpilly). From the larger plateau immediately south-east of the hill, the country below looks quite flat, and is of bare limestone strata, which are continued in circles and sinuous bands of light and dark color in a most picturesque way. Our maps are unfortunately

on too small a scale, to represent anything but the boundaries of the different groups, but on a larger map these bands of limestone even might have been most easily laid down. Fig. 2, on the same Plate, is a view (looking south) of the village and the low undulating hill of Noyanpally (south-east corner of sheet 58). Plateau-hills of limestone and shales capped with *Paneum* quartzites beyond.

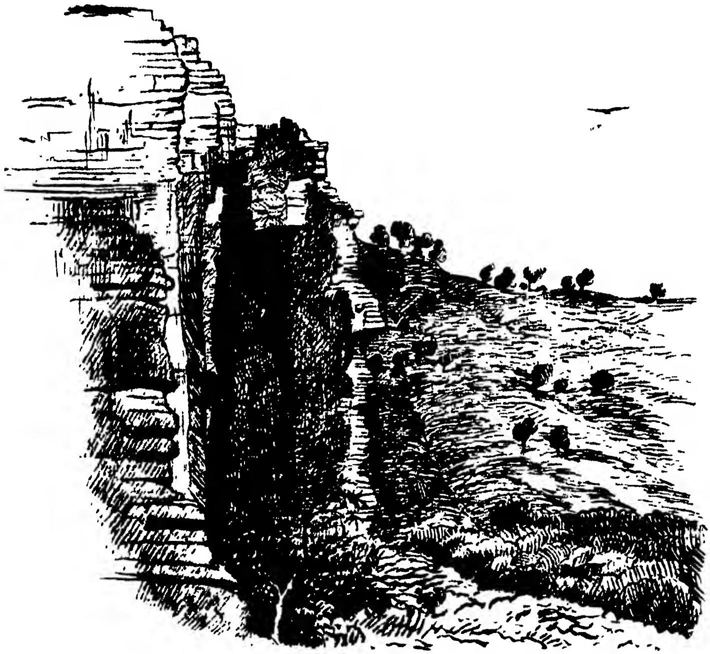


Fig. 10. Buttressed cliffs of Nerjee limestones in the valley just south of Ramwarum Conda, near Banaganpilly. Buttress about 60 feet in height.

450 feet thick.

The *Jummulmudgoo* group varies much in thickness. In the northern part of the field and west of Paneum the two members are thin, showing only about 60 feet altogether. In Ramwarum Conda, west of Banaganpilly, the group attains a thickness of from 400 to 450 feet, and this is about the maximum. Again, south of this there is a tendency to thin out.

Chapter 4.—The Banaganpilly group.

Nearly all round the bases of the inner western hills, and fringing as it were the terraces of limestone described in the last chapter, is a thin series of quartzites cropping out from under the *Jummulmudgoo* limestones. These quartzites are mostly sandstones and grits with pebble beds and occasionally coarse conglomerates; and as these were gradually traced out in their boundary and relations with the other rocks of the country, it was found that some of the beds are quarried at the present day for diamonds close to the town of Banaganpilly. There are, it is true, other diamond workings besides those of Banaganpilly, but nearly all of these are in recent gravels and debris of the original diamond-bearing rocks. The Banaganpilly mines, on the other hand, are in true rock workings; and this condition refers only to such rocks as were found to be on the same horizon with the Banaganpilly beds.

Sands and grits of Banaganpilly.

Until very lately it seemed appropriate to designate this series as the diamond-bearing group, as there was no knowledge of diamonds having been found in any other set of rocks of either the KARNÚLS or KADAPAHS. The old diamond-workings near Oostapully on the left bank of the Kistnah in the Kistnah district have, however, since been visited by Dr. Oldham, when from his observations it appears that they were executed in quartzites which certainly seem to be of the KADAPAH series. A local name, in accordance with the system of nomenclature adopted in this memoir, is therefore preferable, and at Dr. Oldham's suggestion that of Banaganpilly is adopted.

Might be called the *Diamond group.*

Later still, Mr. Foote, in his examination of the same series of rocks in the neighbourhood of Juggiapett,* has likewise observed that

* Frontier town on the borders of the Kistnah district and Hyderabad territory, left or north bank of Kistnah.

the old workings are not confined to any particular set of quartzites either of the older or newer formations of the rocks under discussion.*

Relations with other groups.

This set of quartzites is always regularly overlaid and sometimes overlapped by limestones of the *Jummulmudgoo* group, and it always rests unconformably on any underlying rocks, so that there is an absolute certainty about the different beds of quartzites belonging to the one group so long as it is continuous. Unfortunately there is no particularly distinctive feature in the sandstones of this group which is constant for any time except this one of relation with the rocks associated with it. In constitution the beds vary continually, and they are very like the sandstones and grits of other series of quartzites in the KADAPAH rocks, so that in cases where the continuity of the group is broken, it is very difficult to say if the detached beds are really on the same horizon.

We might even expect the occurrence of diamonds to be a sufficiently distinctive character; but such is not the case, for there are extensive tracts of outcrop in which no diamonds are found, the gangue apparently being only locally dispersed through the group.

Thickness variable, but small.

The thickness of the *Banaganpilly* group is often very small, only about 4 or 5 feet; and the general thickness is seldom more than 20 feet; while there are instances, in the hills north-west of Banaganpilly about Gooraman Conda, and below the Oondootla plateau, of the deposit being from seventy to a hundred feet thick. The group has, however, been very much denuded among the undulations outside and west of the main ranges of hills, so that a fair

* I myself, again, have seen some of the old workings in the Kistnah and Hyderabad countries, and am constrained to believe that they were really excavated in what are KADAPAH Rocks; though there is still the doubt as to whether ***true rock-workings in these beds were ever successful.*** Some of the workings which I have seen were actually in the limestones, or rather in hollows of the same where quartzite, gravel, &c., had collected.—W. K.

estimate can hardly be made here of its thickness; while very often there is only a mere skin of the true diamond-bearing beds left, which itself is frequently in scattered outliers.

Lie of beds.

The lie of the beds is pretty much the same as that of those groups already described, namely, nearly horizontal, or with a gentle hading up to the west; except along the north-west side of the Oondootla plateau where they have rolled down with the other strata in a sharp dip to the north-west, so as to run under the limestones, &c., of the Nundycottoor plains. The floor of the basin over which these lowest beds were deposited was not very irregular. For these grits and sandstones, though so thin as a series, were quite sufficient to fill up the more decided depressions and give a very flatly undulating floor on which the succeeding limestones and quartzites were deposited.

Distribution.

Though so thin, the *Banaganpilly* rocks were apparently nearly co-extensive with the limestone groups, as is shown by traces occurring on the eastern side of the Khoondair valley near Bussuapoor, and by what we are led to consider as the edges of the deposit near Kurnool and along the north or left bank of the Kistnah river.

Our guide in tracing out this group has been mainly the known deposit of Banaganpilly. From it the boundaries were traced continuously westward and right round the westerly edge of the terrace below the scarps of the Oopalpád plateau. The valley running due west from Banaganpilly and thence round to the south-west is so deeply worn through the KARNÚL rocks into those of the KADAPAH formation that all connection with the former to the north is completely cut off. There was, however, no difficulty in recognizing each group again on the opposite side of the valley, so the group in question was traced to the old diamond workings of Gooraman Conda at which point Mr. Foote had taken it up. In carrying on his work to the northwards he was led to

the consideration that some apparently very different looking grits are shore deposits of the same group, with which I am in great part inclined to agree; but perhaps it will be better to give his own notes, so that they may receive their proper value in the clearing up of this point:—

"To the north-north-westward of the Oondootla plateau, no rocks belonging to the diamond-bearing series of the KARNÚLS occur till we reach the west side of the Gardymuddagoo valley, where similar pebbly quartzite beds are met with near Bapulcotoor cropping out from under the *Jummulmudgoo* limestones and rising westward till they form the top of a low ridge of hills running along the right bank of the Toongabudra. On the west side of these hills conglomerates of the series are underlaid by a set of highly altered silicious breccias and calcareous rocks, but their exact boundary has not been fully determined. The pebble beds appear to continue north-westward into the hilly ridge south of Sultanpoor. On the south side of this ridge the silicious breccias and associated limestones and a large sheet of intrusive trap are seen to crop out from under pebbly quartzite beds which apparently form the base of the *Banaganpilly* group. These pebble beds are remarkable for containing numerous small pebbles of pink and reddish felspar undistinguishable from much of the felspar occurring in vein-granite of the adjoining granitic or rather syenitic region. The other pebbles consist of quartzite, grey chert, and red and brown jasper with occasional pebbles of quartz. Along the top of the ridge south of Sultanpoor, these pebble beds are well seen dipping east at a low angle with two or three intercalated beds of greenish grey and pale pinkish quartzite."

"The pebble beds present a reddish brown or purplish color externally when weathered, but are always lighter colored when freshly broken. There is a great difference in the degree of hardness dependant in great measure on the quantity of felspar pebbles and grit, but also on the greater or lesser tenacity and density of the silicious matrix. These felspathic conglomerates are especially well seen east of Beallumpad."

"A low ridge of similar brown pebbly quartzite runs due west along the north side of the Toongabudra to immediately opposite Kurnool, outside of Goondipurla fort. Where it abuts on the river opposite Poodoor, the surface is much and strangely broken up as if it had been worked for some mineral. Possibly the diamond workings below Kurnool, mentioned by Dr. Heyne,* may have been at this very spot."

"Two small outliers of this conglomerate occur at Sultanpoor, one immediately north-north-west of the village, the other about a mile from the fort at Alumpoor;—and they rest with the main mass of these sandstone beds south and east of Sultanpoor directly on coarse syenite of pink or reddish colors."

"These pebble beds extend north-east from near Sultanpoor to Ulloor, and are finally lost sight of west and north-west of Mullyala, where they dip under the *Jummul-*

* "Tracts, Historical and Statistical, on India," by Benjamin Heyne.

mudgoo limestones. East of Sultanpoor the ground is thickly strewed with chert and jasper pebbles weathered out of the conglomerate beds."

"The continuity of these pebble beds is not great, for they thin out rapidly and in several places die away entirely, so that the *Jummulmudgoo* limestone reposes directly on the syenitic rocks, as at Shaitancotta and other places both north and south of the Kistnah."

"On the left bank of the Toongabudrá, the relation of the representatives of the *Banaganpilly* quartzites and the overlying limestone is traceable at intervals for several miles north of Bhyrawunpully. They are here represented by a bed of coarse grit, a few feet thick, tilted up generally at a high angle against the syenitic rocks, and dipping westward. For some little distance south of the village, the line of outcrop is coincident with the left bank of the river, but near Bhyrawunpully Pagoda the boundary trends north away from the river—and a few yards further on a very instructive little section is to be seen where a nullah crosses the road from Alumpoor."

"Further north still, the quartzite has either died out or is denuded away at the outcrop; at any rate it does not appear between the limestone and syenite."

"North of the Kistnah, pebbly quartzites holding the same relation to the *Jummulmudgoo* limestone occur in several places, and there are no reasons for considering these of different age from the diamond-bearing quartzites of the south. A very interesting development of the formation is to be met with at Yemkulloo on the banks of the Kistnah about $2\frac{1}{2}$ miles east-north-east of Mooraconda."*

Doubtful beds.

"Between the village, which is close to the river bank, and the foot of the hill to the north, a thin bed of quartzite is seen dipping under the *Jummulmudgoo* limestone at an angle of 40°—50° southward. About one-half of a mile east of the village the quartzite is replaced by a very pebbly bed, the outcrop of which forms a low narrow ridge† sloping gradually away to the east where it is lost sight of in the alluvium of the river; but it has evidently died out, the limestones being seen to rest directly on the metamorphic rocks exposed in the bed of the Kistnah when the river is low."

"This bed of pebbly quartzite was formerly continuous with the beds capping the narrow flat-topped ridge north of the village; but the continuity has been broken through by denuding forces assisted probably by the rending action of the movement by which the underlying syenitic rocks were upheaved, and these pebble beds raised to an elevation greatly above that occupied by their representatives underlying the limestone formations of the Bowanassy river valley."

"This south side of the main ridge shows very distinctly the position occupied by the pebble beds which were deposited in a hollow of the old granitic basin. The lowest bed resting on the granite is the coarsest, and contains many large pebbles of

* The beds described by Mr. Foote in the following paras. are, I am very much inclined to think, of the KADAPAHS.—W. K.

† The quartzites of this ridge are continuous with KADAPAH strata to the east.—W. K.

jasper (red and brown) and chert (grey of all shades), and a few of granite. The upper beds are progressively less and less coarse. The greatest thickness of the beds in the depression is about 50 feet, the bedding regular, distinct, and very nearly horizontal. The upper beds which overlap and cover those in the hollow are not more than four or five feet thick. The prevailing color of the rock is pale reddish or purplish brown."

"To the north of the Yemkulloo ridge is a belt of granitic rock, a mile or a mile and a half in width denuded of its former capping of pebble beds and greatly eroded because of its coarse texture and friable nature. The granite is in most places highly felspathic and of pale pink color."

"On the north side of this granitic tract lies a low ridge showing, along most of its southern front, a small scarp rarely more than three or four feet high and often less than that. This scarp is the edge of a thin capping of pebble beds which once were continuous with those on the Yemkulloo Trig. station hill. Following it towards the west for about three miles it sinks a little, and a thin bed of brown pebbly conglomerate dips to the south-west by south, and passes under the *Jummulmudgoo* limestone lying north of Jutpoal, showing that it is stratigraphically a representative of the *Banaganpilly* quartzites. The lowest pebble bed exposed resting on coarse quartzo-felspathic granite to the north and north-east of Jutpoal consists almost entirely of granitic debris cemented by a silicious matrix, and is sometimes, when weathered, not very easily distinguishable from the underlying granite: it forms a low anticlinal ridge. Quartz pebbles are extremely numerous in the bottom pebble beds. The color of the quartzite matrix of the pebble beds is very variable, ranging from dirty white to greenish grey and reddish brown. North of Munchulcotta (Munchutialty of map) the pebble beds have passed up gradually but in a very small thickness of beds (2′ to 3′ or 4′) into quartzite of pinkish brownish and purplish color, and here the scarp is higher than further west owing to the greater number of remaining beds."

"Northward of the anticlinal ridge at Jutpoal the pebbly quartzites re-appear on the north bank of the Penthully nullah, but in most places only as a thin skin over the granitic rocks varying from six inches to two or three feet in thickness. This thin layer of quartzite pebble beds is very ragged along the edge of the high ground skirting the bank of the nullah. Here and there where the planing action of the denuding agency (probably marine currents) has been less perfect, low hummocks of the brownish or purplish quartzite remain, showing the gradual passage upward from the pebbly conglomerate into compact quartzite."

"To the east of Penthully the pebbly quartzites are seen to rise up the southern slope of a narrow ridge about one hundred and fifty feet above the general plain, and are cut off suddenly on the north side by a low scarp three to five feet high, which constitutes the northern boundary of this part of the area occupied by the diamond-bearing series. To the north of this Penthully hill commences the great granite region north of the Kistnah."

"The outlier of *Jummulmudgoo* limestones resting on the quartzites south-west of Penthully has been already described."

Possible strata of KADAPAH series.

"The general northern boundary of this area of pebbly quartzites lies at a lower level than the capping of the Penthully hill and runs across the open country in a west by north direction in a tolerably straight line for nearly three miles, when it rises into two or three small ridges 20 to 30 feet high to the south-west of Singuwarrum village. The ridges which have a southerly dip are evidently the remnants of the base of the slope by which the pebble beds were connected with the outlying mass capping the Singuwarrum Trig. station hill. The capping bed on this hill consists of a pebbly quartzite undistinguishable from that on the Penthully hill and parts of the Yemkulloo hill. The rock is of brown or drab color and rather compact. The enclosed pebbles consist of grey cherty quartzite and jasper with a considerable number formed of a curious pisolitic chert. The nearly triangular area of the plateau on the summit of the hill is surrounded by a low scarp, vertical in many places, and from two to six feet high, the whole edge surrounded by the ruined wall of a rudely-built droog or hill fort. The general dip of the capping bed is towards the east, at a very low angle, hardly perceptible except when seen from a distance. The underlying rock is a coarse quartzo-felspathic granite. The height of the plateau above the surrounding country may be fairly estimated at 200 feet, and the well defined table shape of the hill renders it very conspicuous for miles around."

"On the south side of the Toongabudra, west of Kurnool, precisely similar pebbly quartzite occurs between the canal and the river stretching some distance into the bed of the latter immediately west of the village of Niddajood. The bed exposed in the river is only partially conglomeratic in character, part of it being quite compact, of white color with purple laminæ identical with that at Borewellee. It is externally stained a deep rusty brown."

"A good deal of white pebbly quartzite has been quarried close to the canal for the revetment of the bank. The enclosed pebbles consist of quartz, grey chert, felspar, and the pisolitic chert found in the pebble bed on the Singuwarrum hill. This white quartzite is of rather friable texture and is easily broken. The compacter portions are strikingly like the felspathic pebbly quartzite occurring on the left bank of the Toongabudra near Bhyrawunpully. From its position on the south bank of the river it is evident that the bed must dip under the limestone at Kulgootlah."

"In the absence of the evidences furnished by organic remains, the stratigraphic position of these pebbly quartzites, so constantly underlying *Jummulmudgoo* limestones, justifies to my mind the view that they are representatives of the conglomerates and quartzites of the Calwa hills and the neighbourhood of Banaganpilly."*

* Since Mr. Foote's examination of this part of the field, I have had further opportunities of following out the rocks, and have found that the breccia and pebble beds of the capped ridge or spur of the Kistnah-Nullamallays on the north bank of the river are continuous into undoubted KADAPAH strata, in which the pisolitic or oolitoid fragments of chert are very common. These fragments are derived from a series of silicious limestones on which the quartzites containing these breccia beds of the Kistnah-Nullamallays rest unconformably. It is therefore very probable that the breccia beds referred to by Mr. Foote in the last five paragraphs are of the KADAPAH series. At any rate, we must consider the capping of the Penthully ridge and the plateau beyond as of these, though the rest of the shore-beds may, of course, be bottom beds of the KARNÚLS and still contain fragments of the oolitoid chert.—W. K.

Outliers between the Paupugnee and Chittravutty.

Attention has been already drawn to* the occurrence of some flat-topped hills in the western part of the Kuddapah district between the Paupugnee and Chittravutty rivers, which are capped with quartzites and which from the resemblance in shape and the fact of their sides being occasionally strewn with great blocks of quartzite might be taken to be of the same structure and constitution as the flat-topped hills below the Oopalpád plateau. These caps of quartzite are perfect outliers of one or other of the different groups already described; but it is utterly impossible, without a much closer examination than we could make, to say of which one.

They lie unconformably on traps and shales which are known to belong to the KADAPAH formation; and the only other quartzites from which they can certainly be distinguished are those of the pinnacled beds. They are very like the southern outcrop of Banaganpilly beds, and seem naturally to be outliers of it, for both are only lying on KADAPAH rocks; but there is no record of diamonds having been found in them. For the present, it is taken for granted that they do belong to this group, though it is not impossible that they may be plateau beds of the *Paneum* group, or even the intercalated quartzites† of the Nerjee limestones so well and distinctly developed on the Oorchintala terrace.

These doubtful and isolated quartzites certainly resemble the plateau beds very much, but if they be really so, we should have to account for the total thinning out and disappearance of the Owk shales, Nerjee limestones, and *Banaganpillys*, of which there certainly do not seem to be very evident signs along their present southern edge, though they are thinning out. Again, the intercalated quartzites of the Nerjee limestones are thickening along their southern edge in the Oorchintala terrace, while the belt of limestone below them has thinned out, and dies

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* See Part II, Chapter 2, on the *Paneum group*, p 64. † See p. 68, &c.

away in the scarp south-east of the village. There is likewise a certain general resemblance between these and the doubtful beds. The *Banaganpilly* group has also thinned out and disappeared in the scarp south-east of Oorchintala, though it is very decided along the western face of the terrace as an exceedingly coarse conglomerate with grits above. There may still therefore have only been a thinning out of those beds to the eastwards, while they stretched southwards towards the outliers in question. Altogether it is a very open question what these outlying caps of quartzite may be, though the balance of evidence at present seems to be in favor of their belonging to the group under description.

Character of the strata of group.

As already stated, this group consists of sandstone- and grit-quartzites, with bands of pebble beds, and some conglomerates. The sandstones are generally coarse, with often a clayey constitution : occasionally felspathic, or ferruginous ; and usually of dark shades of red, grey, and brown colors. They are, as a rule, thin-bedded. Pebble beds are rather more characteristic of this group than of any of the other quartzite series, the pebbles being small, and often extremely numerous, of quartzite and various colored cherts, jaspers, and hardened shales, evidently debris derived from the cherty and shaly series with bands of felspathic and trappean rocks, on which the group is mainly resting. The diamonds occur in some of these more pebbly and clayey layers or bands : and pebble beds may be very often seen in the unworked areas which are exactly like those whence the diamonds are obtained. There are occasionally sandy shales intercalated with the quartzites, but these are never well marked or of any extent.

In the northern part of the country beds of the *Banaganpilly* group are overlapped by the Nerjee limestones ; most particularly and clearly in the eastern part of the Gooraman Conda valley on the north-west flank of the Oondootla plateau. Here the blue beds, or coralloid limestones rest immediately on the shales and traps of the KADAPAH rocks ; but in travelling along the edge of the north-west scarp of the plateau it is

soon found that the thin beds of the *Banaganpilly* group are cropping out from between the limestones and the KADAPAHS below. Again, further north, about Sultanpoor on the right bank of the Toongabudra, the beds which Mr. Foote considers as of this group are again overlapped by these limestones, though only to a small extent. The limestones show at the village of Shaitancotta on the right bank of the river where they rest directly on granitoid gneiss, while a short distance south the grits of the *Banaganpillys* begin to show and thicken out somewhat in the direction of Sultanpoor. Opposite this point, on the left bank of the river, the Nerjee limestones rest on the grits at Hoopulpad, but as they bend round west of that village and run down under Alumpoor, they are again seen lying directly on the gneiss.

Diamond beds.

From what can be seen of the present workings and those which are old and deserted, the diamonds, or the seams in which the gems occur, are confined to the lower beds, possibly to a sub-division of the group which, however, we have not been able to distinguish with any certainty. At Banaganpilly one can see whence the diamonds are obtained, and partly make out whence they must have been obtained in other now deserted workings; but there are many other localities with apparently identical rocks where diamonds might be expected to be found, but where the people have never tried for them and, what is more, where they do not believe they are to be found.

The true diamond-bearing beds are low in the group, and a closer examination than we could make may even eventually show that they are separable from the strata which overlie them where the seam of quartzites is thickest. There is no separation by shales and limestones as an intermediate band: it can only be a separation by overlap. For instance, the lower beds of the group may not have been deposited over the whole of the bottom of the basin, but here and there in patches, the upper beds having overlapped these—which would be one way of accounting

for the scattered localities of diamond workings; or else the diamond seams may only be locally distributed in the group. On the other hand, the fact of diamond workings being scattered, or not in existence at all generally over the area of these rocks, may not prove the absence of the diamond: the non-speculative character of the natives of this country, and their having been perhaps mainly guided by chance findings of the gem, or their tendency to keep working about the neighbourhood of old diggings until the seam was worked out, or a fresh one opened, are points in favor of the possibility of the diamond being more generally distributed. The people of India are also very much given to the idea that the diamond grows, and consequently are continually re-sifting the old heaps of washed gravel in preference to breaking up new ground.

Banaganpilly mines.

The diamond mines of Banaganpilly have been more or less fully described by nearly all the writers referred to as having examined the rocks of the Cuddapah and Kurnool districts. The most elaborate of these descriptions is that of Dr. Heyne in his "Tracts, Historical, and Statistical, on India," the reading of which will well repay any one who may take an interest in the subject, or feel inclined to search for the precious stones. Our map shows the group of rocks as it now lies exposed on the surface of the country, and I think that nearly everywhere in the area thus delineated, if an approach to the peculiar pebbly conglomerate and breccia in which we know that the diamond gangue is at present worked, be met with—and such are common all over—it would be worth while making preliminary explorations, even though the people of the place were to say that there were no chance of diamonds. They probably would never say this, however, the mere fact of the locality never having been worked being quite sufficient in their eyes against it.

The town of Banaganpilly* is situated on the western edge of the Khoond-air valley at the termination of a low and gently sloping range of

* 15° 19′ North Lat., 78° 17′ East Long., about 37 miles south-south-east of Kurnool.

hills which leads west-south-west up to the much steeper and loftier ascents of Ramwarum Conda. The mines are worked on the lower part of this long promontory, in quartzite beds which rise up from under the plain on which the town is built and form a covering or cap* to the range. This gently rising stretch of hill drops down by steep slopes, on its north side, to plains which stretch in one direction towards the Puspulla valley west of Banaganpilly, thus presenting a scarp of the quartzite covering to the north; and the gentler slope of the south-west side of the low range is likewise partially denuded of its quartzite covering in long bays which open out on the plains south-west of the town. On proceeding up the slope of the hill in a westerly direction, after passing over about two miles of quartzites in which the mines are sunk, it is then found that the capping has been denuded for a short distance, leaving the underlying KADAPAH rocks exposed; after which they again stretch westward, though now nearly horizontally, for some miles and then end in a scarp from whence one looks down on the beautiful tank and very irregularly denuded country below Ramwarum Conda, which is made up of older rocks.

Stratigraphy of Banaganpilly.

By this denudation we are able to get at a thorough knowledge of the structure of this low hill-range of Banaganpilly, and it is as follows. The quartzites of the *Banaganpilly* group form a cap, or rather a back covering, of no very great thickness—10 to 20 feet,—resting unconformably on the denuded surface of a much older set of shales and traps with some limestone bands. The following diagrammatic sections will perhaps better illustrate this arrangement of the rocks:—

* It is worth mentioning that Ramwarum Conda and the plateau range of hills to the north of it are also capped with quartzites, but these are not the quartzites rising up from under Banaganpilly, the latter run under the bases of Ramwarum Conda and the plateau. I am thus particular, as it seems to me that Malcolmson and some of the other previous observers have been induced to look on the quartzites of the plateau in question as 'diamond beds.'—W. K.

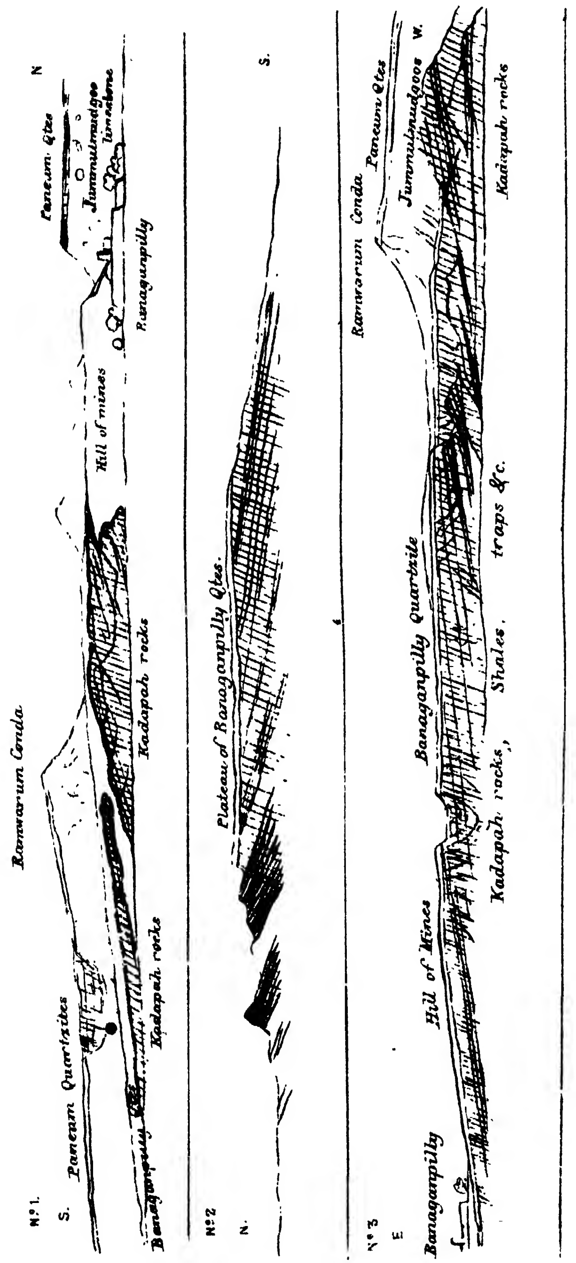


Fig. 11. Diagram sections of Banaganpilly hill. No. 1, is looking west. No. 2, is section of west end of hill. No. 3, is view looking south.

The dip of the underlying shales, traps, &c., is really so low on the northern face of the hill that it is not surprising that previous observers have been led into the error of supposing that the quartzites overlaid these rocks conformably; but had time been allowed them, they would doubtless eventually have made out that this was not the case.

The quartzite covering is from 20 to 30 feet in thickness; and it is pierced here and there over the Banaganpilly end of the hill by shafts of 15 feet or less, from the bottoms of which nearly horizontal galleries are run to get at the seams of diamond gangue. The capping is composed of compact grits and sandstones in thickish beds above and somewhat thinner bedded towards the bottom. Externally the rocks are hard and vitreous. At the level of the galleries there are beds of coarse pebbly conglomerate, occasionally a breccia, which are sandy and clayey, and with these run seams of more shaly and clayey stuff. There is no trace of the clayey constitution on the outside along the outcrop; nor are there any distinct bands of shales; there are only some sandy shales down at or near the bottom of the series. On the other hand, down in the shafts, owing largely to the confined moisture (never to be expected from the atmospheric conditions of the country), heat, and other decomposing influences, the rocks are as unaltered-looking sandstone, grits, clayey varieties of these, and coarse shales as it is possible to meet. It is in these more or less clayey and shaly seams of pebbly beds that the diamonds are found.

In the mines the coolies were picking out a seam of about six or eight inches in thickness, occurring with thicker and harder beds of sandstone, and which they said was the diamond layer; this rock when brought to light turned out to be an easily-broken-up damp clayey conglomerate and partly breccia, of small rounded fragments and pebbles of black, red, green, and pale-colored shales and cherts, and of quartzite with large and small grains of dirty and pellucid quartz. This was the rock extracted in all the mines then being worked.

The gangue is then pounded up, washed, sifted, and laid out to dry on prepared floors; after which the residue of clean sand is carefully examined in the hand, by the women and children of the working parties, for the precious gems.

I saw no diamond *in situ,* nor did I see or hear of any diamond being found during my stay at Banaganpilly for four or five days at a time. Diamonds were brought to me which were reported to have been found in the mines, but these were most disappointing in their minuteness, flaws, and dirty colors. They were generally about the size of small *cholam,* or pepper-corn seeds, and very like those which I had already seen in the alluvial washings of Ramulkota (south of Kurnool). Nearly all the specimens were more or less perfect modifications of the octahedron with curved facets; one of these had each of its facets crowned with a little pyramid of tables, thus:

Fig. 12. Crystal of Diamond.

They were smooth, tolerably bright and shining, and did not look as if they had been worn; in fact, they seemed to me to have been crystals *in situ* in the rock. In color they were pale blue or green and yellow. There were some larger fragments of crystals, which were, however, much flawed. The good specimens were valued by the merchants at Rs. 10 each, perhaps they were worth Rs. 40. I was shown one diamond, a smooth shining crystal of a pale yellow color, with curved facets, about as large as a moderately sized garden pea, and valued at Rs. 350, which was, however, said not to be from these mines, but from near Anantapoor in the Bellary district, where it is almost certain that diamonds are not likely to be found, as the country is one of gneiss rocks. This may really have been a Banaganpilly diamond, for it is very possible that true information regarding the best finds at Banaganpilly was not given to me, considering that it is to the advantage of the merchants to keep down the value of a place in which the right to work for diamonds is let out by Government on contract.

Neither the Nawab of Banaganpilly, nor his followers, nor the Tehsildar of the place, nor the merchants could, or would, tell me of any better diamonds having been found for many years. They said they knew of no valuable diamonds having been found. The coolies said the same, and it is apparently impossible to bribe them to fetch diamonds, supposing that they had secreted any good ones.

The surface of the Banaganpilly hill runs up for about half its distance at from 5° to 10° and then it stretches away westward as a plateau; but only the townward slope has been largely worked for diamonds, the plateau beyond up to the denuded portion of the hill having been only partly worked. Men are still working at the old shafts near the town, while they are lengthening the galleries towards the higher plateau; and old men may be still seen at places re-sifting the discarded gravel heaps in the hopes that a diamond or two 'may have grown.' I do not see any reason to suppose that diamonds may not eventually be found in the rest of the plateau, for the remainder of the quartzite covering is just a continuation of that already being worked. Up till this time further mines have probably not been opened, as there has evidently been quite enough field for exploration near the town hitherto; while there certainly would be more trouble in working the distant ground, as the shafts would have to be sunk deeper and through very hard quartzites.

From the Banaganpilly hill I tracked the diamond group westward until it dips under the Nerjee limestones of Ramwarum Conda at the north-east corner of the Oopalpád plateau; whence it may be seen cropping out all along the south side of the valley west of Banaganpilly, at the edge of the limestone terrace lying at the base of the northern and western slopes of the plateau.

Some sixteen miles west-by-south of Banaganpilly this outcrop runs out for some miles beyond the edge of the overlying limestones, and is spread as a capping over the hills around the now much ruined town

of Moonimuddagoo. Diamond mines were formerly worked here, and the stones cut and polished in the town. The series of strata here is not of any thickness, merely a sort of skin covering the older KADAPAH rocks, at least on that part of the hills where the diamonds were searched for; and the quartzites are very much of the same character as those of Banaganpilly. Over the old working grounds the beds are mainly thin and very pebbly, with chert, &c. I made every enquiry regarding these mines, but could only learn that they had long since ceased to be worked; and the state of the rooted-up ground on the plateau above and north of the town shows this. It is probable that the seam was totally worked out. Southwards of Moonimuddagoo, though I carried this series of quartzites right down to, and possibly beyond, the Penn-air river in the plateau hills of Chintacoonta, I could find no trace, nor learn any tradition, of diamonds having been worked beyond Moonimuddagoo. Possibly there may really be no further diamond-bearing seams in that direction, but the group of rocks in which these seams occur at other places is certainly so continued; and in it are rocks like those now or formerly worked at Banaganpilly, Moonimuddagoo, and the region further north around Gooraman-conda.

Moonimuddagoo mines.

Gooraman-conda.

It is worthy of notice that in the three localities just given, the workers have taken the ground where a large superficial surface was exposed; they have never tried the outcrop, which, if a seam could only be hit upon, would really be a much less troublesome and expensive opening for mining than that of having first to break through such hard and intractable rocks as the upper beds of the group are.

On the eastern side of the Khoond-air valley there is an area of old and deserted diamond workings at the base of the Nullamullays east of Busswapoor, which was, I believe, partly mined and mainly washed.

It is now quite overgrown with bamboo forest, and the villagers have no recollection of the mines having been worked in their time. The bottom of the valley east of the village seems to have been thoroughly washed, for it is full of pits which were once dug amongst the alluvial deposits, and around these are still evidence of the heaps of gravel and dug-out debris. The sides of the hills above are also often broken up in places, as is the case in the mining localities in other parts of the district. It is, however, exceedingly difficult to recognise anything like diamond beds here, for the whole country is made up of quartzites which are most of them certainly of the older KADAPAHS; and it is, besides being jungle-covered, much obscured by debris from the higher ranges of hills. I nevertheless saw traces of a thin covering of quartzites lying unconformably on other altered sandstones and occasionally on the clay-slates which are associated with the older formation; and the rocks of this covering had evidently been broken up. I also at last found a lofty ridge, some distance beyond the valley of mines, which is distinctly capped with other quartzites of grit, sandstone, and conglomerate. There is very little of this capping remaining now; and I can only come to the conclusion that this is what is left of the "diamond group" in this part of the country. This outlier shows beds of pebbly conglomerate and breccia with the same black, purple, green, red, and pale colored cherts and shales as are seen in strata of the known diamond group.

Busswapoor mines.

There are other localities on this side of the Khoond-air valley, further to the south, as near the head of the valley leading up to Murlayconda from Madaypoor, and again on a low rounded ridge at Sultanpet a few miles south-south-east of Roodrar, where diamond beds might be found in the very decidedly marked quartzite strata of pebbly conglomerates and breccias with the usual included fragments of cherts, &c. But there are no traces of mines or any recollections of such

among the people. We were only guided by the extraordinary resemblance between these beds and what are in other places strata of the diamond group; after all, of course, a very weak argument in trying to make out relations amongst the numerous bands of quartzite in our whole series of KADAPAH and KARNÚL rocks.

Ramulkota mines.

The Ramulkota mines, nearly 20 miles south-south-west of Kurnool, included both rock workings and alluvial washings. They are now merely alluvial washings, the material for examination being dug from the edge of the alluvial plain which runs close up to the southern end of the village. In old times, however, the quartzites around the village were quarried, the rocky surface of the rising grounds to the west and along the northern base of the neighbouring Gunnygull ridge to the east-south-east being covered with ruins of pits and heaps of the broken rock. The *Banaganpilly* group, as will be seen on the map, has been left here free from denudation and faulting to some extent.

Other localities.

Before concluding this chapter, it may be useful to give a list of all the known localities of old and modern diamond workings in the country under description. There are one or two which we have never been able to find out, the names of the villages as given by the writers on the subject not being now known. There are likewise some names common to several villages; but we have taken for granted that they are sites of the same name which are either on Banaganpilly strata or adjacent. Three of the localities are rather far from any outcrop of the quartzite in question, are deserted now and gone out of remembrance; and they can only have been alluvial washings, if they ever were diamond producing places. The late Captain J. G. Russel, when Assistant Commissioner at Kurnool, made some very interesting collections of supposed and true diamond

ores from many places in the district; the names of these have been taken from the collections in the Madras Museum. Captain Russel does not seem to have published any papers regarding these collections:

List of Diamond Localities.

CUDDAPAH DISTRICT.

CUNNAPURTEE	Near Chennoor,* on opposite banks of the Pennair. Alluvial washings. Worked at intervals.
WOBLAPULLY	
LAMDUR	Said to be to the west of Chennoor.—(Dr. Heyne).
PINCHETGAPADU	

KURNOOL DISTRICT.

BANAGANPILLY	37 miles south-south-east of Kurnool. Rock workings. Worked.
MOONIMUDDAGOO	16 miles west of Banaganpilly. Rock workings. Deserted.
RAMULKOTA	18 miles west by south of Kurnool ... Alluvial washings. Worked. Rock workings. Deserted.
TIMAPOORAM	6 miles east-south-east of Ramulkota. Rock workings. Worked.
YEMBYE	24 miles south-south-east of Kurnool. Rock workings. Deserted.—(Captain J. G. Russel).
BYANPULLY	
GOORAMANCONDA	
GOODYPAUD	Nundycotkoor Taluq. Doubtful localities.—(Captain J. G. Russel).
BANNOOR	
DEVANOOR	
SHAITANCOTTAH	Right bank of the Toongabudra. East-north-east of Kurnool. Deserted.
DEOMURROOH	Left bank of Toongabudra. Deserted.
TANDRAPAD	Ditto ditto. Alluvial. Deserted.—(Captain Newbold).
BUSSWAPOOR	Nullamullays. Rock workings and alluvial washings. Deserted.

? BELLARY DISTRICT.

WUDJAKAVOOR	Gooty division. Doubtful.—(Newbold).
OOVALUMPULLY	Doubtful.—(Captain J. G. Russel).
PAIPULLY (PAYPULLY) ...	
KUNAMUDDAKUL	

(These villages are possibly in that part of the Bellary district just inside or outside the western boundary of KADAPAH and KARNUL rocks; Piapully is outside the boundary. The workings must in such situations have been alluvial or among debris of the diamond beds which might possibly have been deposited at these places).

KISTNAH DISTRICT.

At various localities in the Palnád. All deserted.

* The old diamond workings of Chennoor and the neighbourhood north of Cuddapah and on the opposite bank of the Penn-air are in recent gravel beds which were derived from the denudation of quartzites. These have been long deserted, but have again been lately taken up by a Mr. Richardson of Madras, who applied to the Collector of Cuddapah for permission to work the ground in the beginning of this year (1869). For the present Mr. Richardson pays a rent of Rs. 100 for the year's working. There is no report as yet of his progress, (July, 1869).

Chapter 5.—The Palnád Beds.

Extreme north-east area of KARNÚLS.

Since the foregoing was written, the survey of the whole area of the two formations under examination has been completed; it was then found that there is a further but detached spread of KARNÚLS in the extreme north-east corner of the area. This is in the western part of the Kistnah district, or, in other words, in the Palnád* and in the adjoining part of the Hyderabad territory. Being, as stated above, a detached area, and there still being that total absence of fossils, it is again only by stratigraphical and lithological tests that these rocks can be affirmed to be KARNÚLS.

Great obscurity in the grouping of the limestones of this area.

There is, however, even a greater difficulty to be met in the correlation of the strata than ever occurred in the much larger area of more typical beds; for supposing that an explorer were to enter the Palnád from the west or south-west of the area, he would be as equally impressed with the idea that the limestones and quartzites over which he was working were KARNÚLS, as another traveller entering from the north-east would become fixed in the idea that the rocks belonged to the KADAPAHS; for, it is, so far as we can see, impossible to draw the line of demarcation between limestones which are excessively alike and which on the eastern part of the field are certainly associated with quartzites of the latter formation, while on the western they are associated to some extent with what seem to be, and what we must consider, newer quartzites; or, in other words, limestones belonging to both formations are now in such juxtaposition, and so altered into a certain material resemblance, that their lie cannot be explained except by faulting, or inversion, or both, or by a violent crushing up of the older strata over the newer.

* To the west of Guntoor, and situated between that part of the Eastern Ghats which is made up of the north-eastern spurs of the Nullamullays and the Kistnah river.

Analogous to strata of limestone on east side of Khoond-air Valley.

It may be remembered that even in the Kurnool and Cuddapah region, *viz.*, along the eastern side of the Khoond-air Valley, the *Jummulmudgoo* and *Khoond-air* strata are more or less turned up on end and squeezed until the limestones in either group occasionally resemble each other, and, as will be hereafter seen, even some of the adjacent limestones of the older KADAPAH are very like to these, and at times are superincumbent on them; so that the Palnád country is not without a parallel in its physical structure. In the Khoond-air Valley, however, there was never any doubt, except for a brief period, as to which were the limestones of each group respectively.

It is possible then that the subsequent alteration and inversion among the strata may have been so much greater in the Palnád than on the east side of the Khoond valley, as to have produced this juxtaposition of otherwise very different series of rocks.

Beds of western part of Palnád, nearly identical with KARNÚL rocks.

It is a fact, at any rate, that more than half the area of the Palnád is occupied by a series of rocks which strongly resemble the KARNÚLS in every way; while it will be seen hereafter in the discussion of the KADAPAHS that there is good ground for considering almost the whole, if not all the Palnád limestones, with their associated quartzites, as of the same formation.

With these preliminary remarks, then, a brief account of the rocks of this detached area may now be given.

In the south-west corner of the Palnád there are unmistakable red purple shales (calcareous) overlying earthy blue limestones, or **Nundial** shales and **Koilkoontlas** of the *Khoond-air* group. These again overlie quartzite sandstones which answer very well to the **Plateau** quartzites of the *Paneums*. Underneath these, comes another set of more compact and crystallized blue, pale-colored, and reddish limestones with occasional traces of non-calcareous buff shales uppermost, which

cannot be distinguished from the 'Owk' shales and 'Nerjee' limestone of the *Jummulmudgoos*. Beneath these again, come traces of quartzite sandstones and conglomerates, answering to the *Banaganpilly* group, and which in places have been worked for diamonds.

The descriptions of composition and structure of the two KARNÚL limestone groups already given are perfectly applicable to these two limestone groups in the Palnád, so that it would be a waste of time to redescribe such similar rocks.

With regard, however, to the two quartzite groups, there is not such a close resemblance. In the strata answering to the *Paneums* there are no representatives of the Pinnacled beds, though there are exact equivalents of the Plateau beds. On the other hand, the lower quartzites are so generally undistinguishable from the quartzites (KADAPAHS) on which they are lying, that it is hard, without a long and very close examination, which we could not devote to them, to say whether they are really true KARNÚL quartzites or not.

A further small detached area on Kistnah plateau.

There is yet another exceedingly small and detached area of limestones situated about 10 miles further south-west than the extreme south-west corner of the Palnád, just at the bend which the Kistnah makes before running due north for some miles of its course. These beds are undoubtedly the same as the lower limestone in the Palnád, and are lying apparently quite conformably on the nearly horizontal quartzites of the elevated plateau through which the river flows in that region.

Lie of Palnád strata.

In the Palnád, the rocks under consideration are lying in a flat basin with only a few easy undulations, from which all but apparent traces of the bottom quartzites are denuded; the low hills towards the south-west corner of the field being thus partly made up of what look like *Banaganpillys.*

The range of low hills of the Oopullapad station is nearly completely surrounded by a rim of outcrop of the *Banaganpillys,* as also the range to the north.

Traces of diamond beds.

Along the eastern edge of the Timmerycota range, there are traces of old diamond workings, more particularly and decidedly around Mullawarum on the right bank of the Kistnah, where the limestones lapping round the base of the hill have been regularly undermined to get at the quartzite beneath them containing the diamonds. Here there certainly seems good proof of the existence of a set of diamond-bearing beds, perfectly distinguishable from the other quartzites of which the rest of the ridge is mainly made, for the debris and other evidence of the old workings is strictly confined to the edge of the limestones.

Again, in the Sarangapully hill further to the east-north-east, on its eastern side near the Kistnah, there are traces of old diamond workings close to the overlying limestone.* There are no workings carried on now in the Palnád; and a very old Mussulman in Timmerycota informed me that there had been no workings in his day. These works date from the time when the Palnád was under the Mogul rule.

Cleavage in Palnád limestones.

The great spread of limestones in the Palnád, which may at present be considered as *Jummulmudgoos*—the *Khoond-airs* showing only over the south-western part—is over more than half its area very strongly cleaved, the cleavage showing stronger and stronger to the westward until the beds, where they were more earthy and clayey, are almost slates. The cleaved character is confined to the area east of Goorjal, and along

* It must not, however, be forgotten that both Dr. Oldham and Mr. Foote have seen old diamond workings in various quartzite strata, further east even than this, in the Batavole or Juggiapett range of hills, some of which strata certainly belong to the KADAPAHS.

the base of the Waumyconda where it shows in the *Khoond-airs* as well as in the *Jummulmudgoos*. The cleavage, at the same time, seems to be strongly developed in a certain set of beds, rather than along a particular run of country irrespective of the succession of the strata.

The cleaved limestones in the present cases are identical with the limestones on the eastern side of the Khoond-air valley, *viz* :—dark-grey subcrystalline banded limestones, rather clayey. The bluer and more compact beds are also cleaved but not so strongly. The banded and cleaved strata show in a great spread of rock in and between the Goorjal and Datchapully streams. Cleavage strikes north-east-south-west with a dip of 20° to 30° south-east; and it is very often so strong as to have nearly obliterated lamination and bedding.

That cleavage here is the result of pressure, is often very well seen in the peculiarly toothed or serrated surfaces of lamination exhibited by the beds of limestone, as in the following diagram.

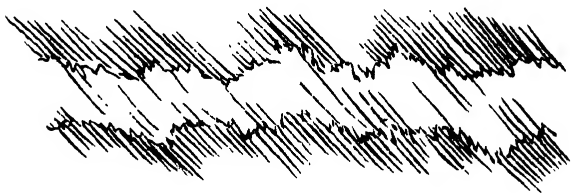


Fig. 13. Serrated surfaces of the beds of limestone, resulting from cleavage.

Here there has clearly been pressure from the south-eastward, sufficient to crush up the surfaces of the beds, or rather bands, of dark and lighter earthy or other limestone into the serrated ripplings displayed in the section; and these little ridges are parallel to and in the planes of cleavage. Pressure applied at right angles to the cleavage planes would have a tendency to produce this serration of lamination surfaces, more particularly as the general dip of the beds is to the south-east, and probably was so when the pressure was superinduced.

The edges of the suture-like partings are generally weathered of a brown color, and the partings themselves are occasionally filled in with carbonate of lime.

Deceptive succession of limestone strata.

The most strange and embarrassing feature about the eastern and north-east part of the Palnád area of limestones is the apparently generally steady dip of the beds to the south-eastward, and the apparent intercalation of several bands of slates and talcose schists with much white quartz; while along the north-west edge of the field on the left bank of the Kistnah there is no evidence of such great succession of beds.

Apparent strike of beds not parallel with shoreward edge.

For a good part of this north-western boundary the limestones, with underlying shales and flags, lie quite naturally up over the quartzites beneath, so that were the limestones and slates of the western part of the area, which is a nearly level plain, in proper succession, the successive outcrops ought to trend round from their usual north-east-south-west strike more to the east-north-east so as to be parallel with the north-west boundary. Such, however, is not the case; for after getting (on the left bank of the Kistnah or in the Hyderabad territory,) as far east as the Vaiml-air river—up to which point the limestones are not cleaved, while their outcrop runs parallel with the boundary—the strata then begin to show cleavage strongly, and very shortly afterwards give a strong north-east-south-west outcrop with a steady dip to the south-east. This steady outcrop dies out, however, close to the boundary, and the strata are striking regularly with the slates and quartzites below; the cleavage, which is about north-east-south-west and dips south-east, nevertheless remaining constant through limestones and shales, the latter being now more slates than shales.

Then again the limestones, slaty-shales, and bottom quartzites follow each other at their boundaries in a tolerably parallel way round the extremity of the Battavole or Juggiapett promontory of KARNÚL and KADAPAH rocks.

Now, had there not been this parallelism of boundaries, and apparent conformability* of strata round the edges of the Palnád basin, the great succession of strata in the Palnád itself might have been accounted for by a case of direct unconformity of the limestones and slates on the bottom quartzites; such an amount of unconformity is not, however, displayed anywhere over the field.

General dip eastward, under quartzites of eastern ridges.

Again, when a section is run across the strike anywhere in the eastern part of the Palnád to the south of the Kistnah, there is apparently an unbroken succession of strata, one over the other, until they, as a general rule, dip down under the rocks forming the eastern hill ridges which bound this side of the Palnád.

Exceptions to this.

They do not, however, always dip down under these eastern rocks; on the contrary, they are in one or two places lying over them, as in the more westerly of the two ridges west of Bellamkonta. Here, at the southern end of the ridge, the limestones are dipping down to the east by south at 30° to 40° under the quartzites; while at the northern end the quartzite ridges are as clearly dipping to the north-west, and close to the base of the ridge the limestones are dipping away at easy angles in the same direction. In the middle of this ridge the quartzites with slates are vertical, so that there is an axis of tortion running up the ridge. Indeed, all round this neighbourhood, the limestones (if they are always the same limestones) and quartzites are most strangely associated together. To take only the next westerly ridge, at its southern end, limestones are overlying and underlying the quartzites of which it is

* The limestones and shales are really unconformable over the quartzites, as will be shown further on, but not nearly to such an extent as the present aspect of the limestones seems to indicate.

composed,—an arrangement of strata, which can only be explained by faulting or inversion, thus:—

Fig. 14. Diagram section at eastern edge of Palnád.
l. Limestone, KARNÚL. *q.* Quartzite, KADAPAH.

Again, the next succeeding ridge has limestones under the quartzites at the southern end, and limestones over the quartzites, further north on both sides of the ridge.

Further north again, opposite Ketavaram, there is an altogether new feature in the relations of the rocks, for limestones, apparently of the same series as those to the south along the western bases of the ridges, are here overlaid by an immense thickness of slates with several bands of quartzites which make up the great Pulichinta ridge. And to all appearance this great mass of slates and quartzites stretches up north north-east, and overlies the limestones south of Batavole or Juggiapett, which at this point are greatly thinner than they are under the slates, &c., opposite Ketavaram if the lie of the beds between Ketavaram and the north-west boundary be taken as the true succession.

In the quartzite ridges of the south-eastern angle of the Palnád, the limestones still hade under the quartzites; while, on the other hand, the limestones of the southern edge of the field lie up over the quartzites of the Waumyconda range.

Considerations on this anomalous stratigraphy.

These sections would seem to indicate that if we accept the limestones as all referable to one series, then it is hardly possible that the quartzites belong to one horizon. It is tolerably certain that there are represent-

atives of two or more series of quartzites; but it is also certain that ridges of one and the same set are both underlaid and overlaid by limestones which are to all appearance one and the same.

There are no direct evidences in the field that the limestones are different, and yet it is most difficult to reconcile the peculiar arrangement of these beds with the supposition that they are all of the same series. I am myself inclined to look on the beds along the greater part of the eastern border of the field as different from and altogether older than those west of the Piddoogooralla tributary of the Kistnah, though I confess myself unable fully to describe the differences. They certainly look more like some older limestones which are hereafter to be described; and yet they are in many cases exactly like limestones of the *Khoond-air* and *Jummulmudgoo* groups of the formation now under description.

It must not be forgotten that the limestones of the south-western part of the Palnád are very similar in their lithological and stratigraphical relations to those of the KARNÚLS; while it remains to be shown that there is no exhibition of like associated strata in the older rocks, except what we see adjacent to the eastern ridges of the present field.

One feature seems certain,—that the quartzites of the north-western slopes of the Waumyconda ridge and of the north-western edge of the basin, along the left bank of the Kistnah up to and south of Batavole, are the same series; while the limestones overlying them are in like manner of one series.

These quartzites in the Waumyconda range overlie other limestones of the KADAPAHS, which may possibly be the same as those that are subjacent to the quartzite ridges west of Bellamkonta.*

* It is part of the argument to state that Mr. Foote, who surveyed the Batavole promontory of rocks, is perfectly convinced in his own mind that the limestones of that region belong to the older series or KADAPAHS; and he saw no reason to alter his opinion after he had traced the same beds with me south-west along the left bank of the Kistnah.

Attempt at solution.

After this statement of the anomalous stratigraphical features which beset the investigator in the examination of the Palnád rocks, it becomes necessary to offer some solution of the puzzle. But, so far, we confess to being unable to do this except by what is little better than a number of speculations founded on the sections and other features displayed by the rocks.

The most reasonable way is of course to seize on the simplest form of explanation, *viz.*, that the great spread of limestones is really a regular succession of strata one over the other in proper order going from north-west to south-east, and that the quartzites of the Bellamkonta ridges are not locally inverted, but really overlie the limestones. Could this be shown to be the case, there would then arise two conclusions, either that the Palnád rocks are all of the older or KADAPAH series; or, that the KARNÚLS assumed in this region, not only great variations in the characters of their four groups, but altogether a greater number of these, and likewise that they here are largely intercalated with slates, as, for instance, in the section across the lofty Pulichinta ridge of hills (see Mr. Foote's sections in notes on the Juggiapett field, in the Appendix).

Considering, however, the cónstant character of the KARNÚLS over such a great area in the Cuddapah and Kurnool districts, it would seem safer to decide that all are KADAPAHS rather than that such very differently associated kinds of rocks as those in the eastern part of the Palnád are KARNÚLS.

Then, again, it is as difficult on either view to account for the presence of quartzite of the same series being at once above and below the limestones.

Palnád limestone may be partly of KARNÚLS and partly of KADAPAHS.

It seems to me that the balance of argument is in favor of the limestones not being all of one series; and that where undoubted cases occur of the same limestone being both above and below the same band

of quartzites, then there have been inversions of greater or lesser extent, as well as faulting to some degree.*

Impossible to show lines of demarcation.

But the difficulty under which we labor is to say where the line or lines of demarcation between the two limestones are to be drawn, or to indicate the possible line or lines of dislocation which may have brought the limestones into juxtaposition.

As stated already, no traces of such lines occur in the limestone area unless those shown by the irregular and wavy outcrop of two bands of slates and talcose schists with quartz which show along the valley of the Piddoogooralla river, and again in the valley of the next main stream to the west, or that which runs past Pinhúlly. In these outcrops, however, there are no good signs of faulting: the slates appear to lie naturally with the rest of the strata. Indeed, it is possible almost to trace the Piddoogooralla slate band, as it runs round between limestone series, in waving curves, with the denudation of the surface of the country.

Karampudi break in succession of strata.

At Karampudi†, however, there is an end to the regularity of the limestones and band of slates, for they lie over the Karampudi beds, though nearly up to that they have haded up from under the limestones to the south and south-east.

Continuity of eastern outcrops broken by cross faults.

When the limestone and slate outcrops of the eastern edge are mapped out, there are certain breaks in their continuity of strike occurring at the westerly continuation of the cross-faults; and these lines of dislocation are indicated on the map as far west as the breaks in the strata would allow of their being supposed to exist.

* It will be seen, further on, how great inversions are frequent and splendidly exhibited in the side gorges of the Waumyconda range of hills, the influence of which may have been impressed upon the strata of the country, thence up to Batavole. The limestones of the western half of the Palnád lie over these quartzites, and they may even have existed covering the range before the great dislocation and squeezing of strata had occurred.

† A few miles west of the south-east corner of Palnád.

The outside boundary, between these KADAPAH and KARNÚL rocks and the crystallines of the Bellamkonta country, is nearly for its whole length a faulted one; the downthrow having been on the west side, but it is a matter of extreme doubt how the fault-plane haded. If, as I suppose, there had been folding and inversion of the strata consequent on a crushing up of the country from the east, then the dislocations must have taken place in the axial planes of the inverted curves, and thus there would be a general hade to the eastward, the newer beds being thus at many points slid down underneath the older ones.

Outer eastern boundary faulted.

This form of fault would account for the lie of evident KADAPAH quartzites over as evidently KARNÚL limestones; and also for the apparently enormous thickness and regular succession of limestones in the middle of the Palnád, which is totally inconsistent with their real strike and an *overlie* of the quartzites. One point is certain,—if there be a real overlie of the quartzites of the eastern ridges, they are perfectly conformable in the separate sections, while at the same time, on the whole, they overlie different horizons of the limestone strata.

Downthrow of rocks on west side, with a hade to the eastward.

The following solution of the obscure stratigraphy of the Palnád beds is advanced, though with extreme distrust as to its being a possible settlement of the relations of these beds:—There was general inversion and faulting of both KADAPAH and KARNÚL rocks along the eastern edge of the Palnád. In the Waumyconda range up to Karampudi the KARNÚL strata are lying naturally on the highest group of the KADAPAH,* which is here unconformable on the next lower group† of slates in the southern slopes of the range. The slates and shales overlying

My idea of the relations of the Palnád beds.

* Called in future pages the *Kistnah beds.*

† Cumbum slates of the *Nullamullay beds.*

the Karampudi limestones are possibly representatives of the *Khoond-air* group of the KARNÚLS.

East of Karampudi, where the quartzites of the hill ridges are *overlying* limestones, there was inversion, by which the Waumyconda quartzites are folded back over the Palnád limestones. There is in these eastern ridges a thin series of shales and slates between the quartzites and the limestones, answering to the shales and slates of the left or north bank of the Kistnah valley. Beneath these come the limestones of the eastern slopes of the western ridges. Lower still come the quartz-stringed greenish slates, talcose slates, and slaty shales of the Piddoogooralla stream valley, and beneath these again comes the great spread of Palnád limestones.

Now, the slates of the Piddoogooralla valley are apparently those which overlie the Karampudi limestones; and they are probably in this valley doubled on themselves, forming the nucleus of a sharp inverted fold, thus :—

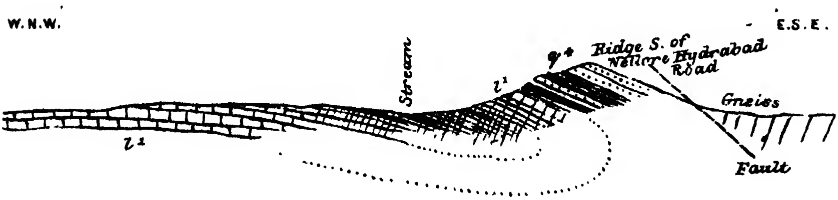


Fig. 15. Theoretical section of eastern part of Palnád, south of the high road from Nakarikallu to Hyderabad. l^1= *Jummulmudgoos* (KARNÚLS). q^4= *Kistnah beds* (KADAPAHS).

Under this view, the whole of the Palnád limestones belong to the KARNÚL series.

The slates and slaty shales of the Piddoogooralla stream valley, and in fact of the whole of this side of the Palnád, owe their ancient and KADAPAH-like aspect to the influence of the crushing forces that produced

this folding and inversion. This slaty look gradually ceases to the westward; and the shales then become like those of the KARNÚLS in the typical field.

Unconformity of limestone of Palnád on the quartzites beneath.

The general, though slight, unconformity of the limestones of the Palnád is clear in this way; that they overlie portions of different beds of the KADAPAH quartzites. On the north-west slopes of the Waumyconda range, and its westerly continuation in the hilly part of the north-south arm of the Kistnah, the Palnád limestones are lapping up over upper strata of the series of KADAPAH quartzites. Again, in the low range of quartzite hills north of the Oopullapad undulation, the northern slopes are scarped to a slight extent, showing intermediate bands of shales and flags, below which are lower beds of this KADAPAH series which fill up the valley between this range and the next rise before reaching the Kistnah river. In this hollow, the limestones are lying on the lowest beds of quartzites (here denuded in one or two spots down to the gneiss itself).

Now, if the limestones originally lay all over these undulations, they rolled up over the low scarps of slates and flags above referred to, until they joined the beds in the next southerly hollow which rest on quartzites higher than the slates and flags. Indeed, it is plain all round the edges of the quartzite undulations in the south-west part of the Palnád that the limestones are unconformable, for they are tailing up nearly horizontally over curved beds of quartzites, thus :—

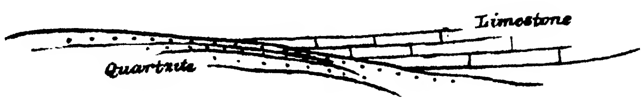


Fig. 16. Unconformity of limestones and quartzites in Palnád.

In the northern portion of the Palnád, however, or along the left bank of the Kistnah valley, this unconformity is not at all so evident,* for the bottom quartzites are lying quite easily, and have apparently scarcely been disturbed since the period in which they were deposited. Still, immediately south on the right bank of the Kistnah, and indeed also in its continuation on the north side, the Sarangapully hill is lapped round by thin limestones, higher and higher beds—particularly at the southern and west side of the ridge—lying up against the quartzites of which the ridge is composed.

The chocolate colored shales, eventually becoming slates to the eastward of the Sarangapully undulation, are evidently part of the limestone series; they scarcely show to the west of this ridge, clear subcrystalline grey beds of limestone there lying up over the quartzites. This coming in of a set of shales at the bottom of what I take to be *Jammulmudgoo* limestones is hardly in accordance with the general behaviour of the same group in the Kurnool and Cuddapah area; nevertheless it is not quite without a parallel, for there are cases of earthy and sandy bases to this group on the western outcrops below the Oopalpád plateau of the Banaganpilly and Baitumcheroo country.

Mr. Foote's views regarding the Palnád limestones will be found in his notes given in that part of this memoir which is devoted to the consideration of the KADAPAH formation *(see appendix)*.

CONCLUSION.

The KARNÚL formation has now been described in its entirety; it is not of much thickness, altogether in its greatest development being only 1,200 feet, but it is superficially very extensive, and it is admirably displayed, both horizontally and vertically. There is no difficulty, after examining it carefully, in distinguishing it as a formation; for, as we have seen, it is lying flatly on the up-turned edges of the rocks which are next to be described.

* This is the part of the field examined by Mr. Foote.—W. K.

Though it is essentially an altered series of rocks, and must thus necessarily have been placed under conditions utterly different from those we now find it in,—such as having been frequently depressed and elevated, stages of physical change which are shown by its present situation and by the alternate constitution of its component members,—it is a formation exhibiting very little change from its original lie. Even now over nearly the whole field, we only see rocks situated, as they might have been originally deposited over the bottom of an aqueous basin which must at the time have possessed very much the form of the present surface. All round the boundaries there are the evidences of long shelving shores on the edges of this basin; and the more detrital rocks contain fragments of the older deposits that are cropping up immediately along the shores. Doubtless there are many instances in which the detritus must have travelled long distances; but the main constitution of the beds can all be accounted for from adjacent rocks.

Of faulting to any decided extent which has affected the KARNÚL rocks there are only two examples. The one has taken place in a nearly east-west direction along the Gunnygull ridge, east-south-east of Ramulkota, and the northern flank of the Oondootla plateau. It is a fault the throw of which commenced imperceptibly at the eastern end of the line near Gunny, until at its western end, it amounted to more than 300 feet. Along the flank of the Oondootla plateau the limestones and quartzites are bent down with a sharp dip, as is described already in Mr. Foote's account of the 'wall' of Calwa; which dip, as one proceeds westward, is found to become so sharp as to indicate a decided fracture in the strata; and this becomes more and more distinct the nearer the Gunnygull ridge is approached. At first, after the sharp roll-down of the beds is traced out past Calwa, it is found that the Nerjee limestones are brought sharp up against a scarp of quartzites (pinnacled beds) of the *Paneum* group without having any room to slip under them, as they ought to do; and then as the line is traced still further westward the *Banaganpilly* quartzites

begin to crop out from under the limestones at very nearly the same level as the pinnacled beds (which still, however, keep their own level along the north side of the fault) until they run well over the upland country towards and almost on to the Gunnygull ridge, when the pinnacled beds show down below in the flat Kortycoonta plateau north of Gunnygull. Also, the *Banaganpilly* group is again found on this north side of the fault 300 feet below at Ramulkota, where it has cropped out from under the limestones, Owk shales, and pinnacled quartzites of the Kortycoonta plateau. The downthrow then was on the north side, and this is evidenced by the up-turned beds against the northern flanks of the Gunnygull hill. This line of fault runs right out in a westerly direction into the granitoid gneiss country beyond this western edge of our rocks, as is shown by the ridge of fault-rock striking through Yeldoorly hill.

The other instance of dislocation is that along the eastern side of the southern part of the Khoond-air valley. This also was a fault or series of faults which gradually increased in intensity from simple squeezingup of the strata—as previously noticed in a description of the effect produced on the limestones and shales of that part of the valley—to absolute dislocation and faulting at the south-eastern corner of the Cuddapah basin. Unfortunately it is as yet impossible to give any definite opinion as to the amount of faulting which may have taken place at the southern end, or at the east-south-eastern corner of the Cuddapah basin, but there is evidence to show that it may have been considerable either in the horizontal 'heave' or in the vertical 'throw'; for the strata of the region are very violently contorted, intensely vitrified, largely impregnated with quartz and iron ore, and partly squeezed out of sight altogether. For the present it is only necessary to refer to this disturbance in so far as it has affected the KARNÚL rocks, and this was in the gradually increasing folding of the strata and the production of cleavage to a large extent locally.

PART III.

CHAPTER I.—THE KADAPAH FORMATION.

KARNÚLS rest quite unconformably on another series of rocks.

While the country to the west of Banaganpilly was being surveyed, it was found that the group of quartzites at that town in which the diamond mines are excavated rests on the up-turned edges of a series of slaty shales with bands of limestone, accompanied by trap flows and other ancient volcanic deposits, such as ash beds and fine muds. Further investigation showed that these shales, &c., formed a group in a totally different series of rocks, and that the above unconformity is general all over the great area of country now being treated of.

These same Banaganpilly beds are also seen to be lying nearly as unconformably over other strata of the older series as in the Gunnygull ridge to the south of Kurnool, and again further south, about half way to Banaganpilly. In these three instances of Banaganpilly, Gunnygull hill, and the intermediate country, quartzites of the lower group of the KARNÚLS are lying over three different groups of the older series. There are likewise other examples,* but these are not so clear as those just instanced.

Further, the Nerjee limestones stretch up over quartzites of the hills around Jummulmudgoo, as they likewise do over the beds of the low Gardymuddagoo hills east of Kurnool; and, lastly, they are superincumbent

* As in the Goolcheroo hills to the south-west of Cuddapah, where there are patches of quartzite lying clearly unconformably over other quartzites of the older rocks. These patches are doubtless of the same rocks as the flat cappings of the outlying hills (see pp. 52-94) to the south-west of the Gundycotta hills. The outliers on the low northern slopes of the Goolcheroo range to the south-west of Cuddapah town form the rather marked and picturesquely rugged run of rocks so well seen in the view in that direction.

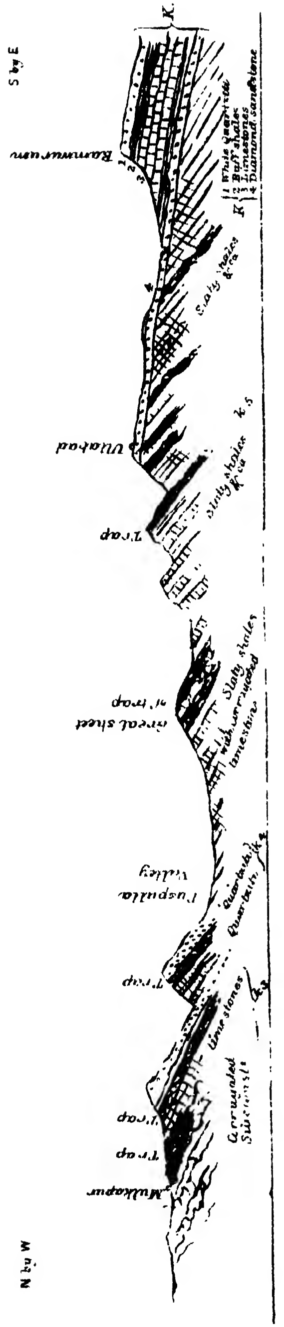


Fig 17 Sketch-section from Mulkapoor through Ullabad to the Ramwarum range

k=KARNULS.

k=KADAPAHS.

on the slates with trap in the eastern end of the Paneum range of that district. On the eastern side of the Khoond-air valley, the same limestones are lying up over quartzites of the flanks of the Nullamullays which are of a different group altogether from any yet mentioned.

Sections showing general unconformity.

The sections 1 and 2 (see Plate of Sections) show this general unconformity where it is perhaps most plainly visible: and the accompanying sketch (Fig. 17) exhibits its effect on the scenery of the country. Other sections illustrative of this relation of the two formations will be met with as the description progresses.

KADAPAHS, a complicated succession of quartzites and slates.

This greatly older series of rocks constitutes the KADAPAH SERIES of our classification, and it is essentially a succession of quartzites and clay slates; the latter having limestones frequently associated with them, and in one particular group a great thickness of trappean rocks and their associates. But this succession is not a simple and uniform one like

that of the KARNÚLS, but rather a complex and broken one:—complex, because many of the groups of rocks change in their character as they are followed out, sometimes with great difficulty and frequently doubtfully, in their display over such a large extent of country, and, in that while over one-half of the field they lie easily and regularly almost as groups of strata deposited in a marine basin, in the other half they are folded and crushed frequently to an enormous extent, and at times faulted very largely: broken, in that cases of unconformity and overlap occur between at least three sets of strata.

These unconformities are, however, not so great as to necessitate the division of the series into separate formations: indeed they are often so obscure that no unconformity is locally recognizable, a feature which is probably in great part due to the folding which the formation underwent prior to the deposition of the KARNÚLS, and the subsequent general alteration, or sub-metamorphism of both. At any rate, the unconformity is plainest where there has been least movement, as on the western side of the country.

Series divisible into four groups.

The series may in this way be arranged in four groups, three of which are well-marked, in the following descending order:—

KADAPAH FORMATION.	*Kistnah group* 2,000 feet. ...	... Sreeshalum quartzites. Kolumnullah slates. Irlaconda quartzites.
	Nullamullay group ... 3,400 feet.	... Cumbum slates. Byrenconda quartzites.
	Chey-air group ... 10,500 feet.	... Poolumpett slates. Naggery quartzites.
	Paupugnee group ... 4,500 feet.	... Vaimpully slates. Goolcheroo quartzites.

Kistnah group.

The *Kistnah* group thickens, and stretches well beyond the group beneath it, on to and over the CRYSTALLINES or GNEISSIC SERIES, and is well displayed over

that part of the field traversed by the Kistnah. Besides the fact that there is an overlap, there are some grounds for considering that the series is unconformable to the subjacent group.

Nullamullay group.

The *Nullamullay* group, as the name implies, is largely developed in the principal range of mountains in the district. It is unconformable to and extends beyond the edges of still lower quartzites and slates.

Chey-air group.

The subjacent group is traversed by the Chey-air, after which river it is named, more particularly as there is no large town in the field by which to distinguish it.

Paupugnee group.

The lower beds of this group again extend far beyond the southern limits of the *Paupugnee* strata, and likewise rest on their denuded edges.

This lowest group finally reposes on the floor of granitoid gneiss of the ancient KADAPAH sea: and it is now most characteristically seen on that part of the course of the Paupugnee to the west of Cuddapah town.

Difficulties in the way of grouping the series.

The grouping of this formation was for a long time a very difficult matter, for, until the whole area had been completely surveyed, the different series of slates and quartzites could not be traced into connection or association. As it happens, the KARNÚL rocks cover up almost the whole of the middle of the field, and thus the absolute tracing out and connection of the various outcrops of the older strata which are so well seen in the eastern and western portions of the country was to some extent impossible. Then it was found that some of the groups on either side could be just connected or run into each other at the northern or Kistnah end, or partially in the middle of the area.

At the Cuddapah edge of the field, this connection is not capable of being perfectly traced, owing to a series of small faults, but there are lithological and stratigraphical features here displayed which are

sufficient, with what is seen along the northern edge, to give reasonable grounds for believing the groups on either side of the faulted break to be the same.

Lie of the series.

The KADAPAHS were deposited apparently in a great gulf, the western shores of which are still extant, very nearly to their ancient limits; but the eastern shores and their strata have almost completely disappeared, having been greatly crushed up, abruptly cut off by a series of faults, and very much denuded. This latter edge of the formation is then a sharp and abrupt one, running generally in a nearly north and south line. Along this line also the strata generally dip right at the crystalline rocks outside, instead of, as on the western side, shelving easily up against what was once a roughly undulating sea bottom.

With this crushing or squeezing up and faulting of the strata along the eastern side of the country, there has been a correspondingly enormous amount of undulation and reduplication, until it is often almost impossible to make out what sets of strata are every now and then coming to light, especially when it is considered that there is not the slightest palæontological evidence to fall back upon.

As a consequence to a great extent of all this squeezing and crushing, and of the constitution of the rocks, there is a large development of slates over the eastern half of the field, while the sandstones (quartzites) even are occasionally very much cleaved.

On the other hand, the strata of the western side are lying tolerably easy, and there is only a very poor show of slates, the non-arenaceous rocks being in the condition of shales or slaty shales.

General easterly dip.

An eastward dip is maintained in a general way throughout the whole area of the KADAPAHS, though there is much folding and reduplication; the foldings are often doubled over, which of course reduces the thickness otherwise deducible from the apparently persistent dip. In addition to this,

however, there is apparently a marked general undulation in the eastern or mountain region which seems to have been originally given to the lie of the strata by the irregular form of the floor of the basin over which they were deposited; for the lower groups rise up to the surface and form the higher ranges of the Nullamullays in the northern part of the area, while the great group of the Cumbums forms the larger part of the hilly country to the south, as in the eastern water-basins of the Penn-air and Chey-air.

N. S. undulation due to original form of floor.

The lie of the slates and quartzites in this mountain region, especially towards the north, is characterized by very peculiar ellipsoidal undulations; the largest of these is the great mountain mass of the Eeshwarnacoopum,* where the strata are lying up the sides and cropping out round the base of the mountain like the coats of a great onion. In Mr. Foote's descriptions it will be seen how frequent these ellipsoids and domes of undulation are in the neighbourhood of Cumbum and along the eastern edge of the country far to the north-east of that town. The Vinukonda and Nakarikallu domes are very characteristic: here the KADAPAHS have thinned out, and as these domes were denuded, a run of quartzites is seen encircling the great nucleus of CRYSTALLINES. The Nakarikallu dome is completely insulated by gneiss; this is apparently due to faulting on six sides, thus giving an irregular hexagonal† outline.

Ellipsoidal undulations, or 'domes.'

The constitution and lie of the different groups of rocks are indicative of several features in the history of this ancient aqueous basin. Along the western shores are immense deposits of boulders, shingle, gravel, and sand which gradually become finer sandstones the further they are found from the

Conditions under which the deposits were formed.

* North-north-west of Cumbum.

† The distinction drawn between slaty or cleaved shales and slates in the present memoir is, that slates are such rocks as have had lamination and bedding more or less obliterated and in which cleavage is so strong that the rock does not split up on planes of lamination, as in a shale for instance, in preference to planes of slaty fracture.

old shores; all evidencing river feeders from the westward, and powerful denudation over a rugged coast almost close to the water's edge.

Subsequent to this was a period of local formation of clays and shales, rapidly succeeded by calcareous deposition with possibly an intermittent flow of thermal waters as indicated by numerous bands of silicious matter consisting mainly of peculiar minute concentrically layered globules which give the rock sometimes quite an oolitoid character.

These deposits were then brought under the influence of denudation which, by the way, must have been more of a marine than subaerial character, for, except to the south-west of Cuddapah town, there are no traces of any valley erosion along the outcrop, the floor now seen having apparently been planed down very uniformly.

Upon this denuded floor were deposited successive groups of sandstones and shales, with intervals of limestone formation; during which time there was a period, or perhaps two periods, of volcanic action, the rocks of which were confined to certain parts of the basin.

The area of deposition at this time too was more extensive northward and southward than that of the first period; while it seems probable from the strongly detrital character of the quartzites and even of the limestones to the southward, together with the evident thinning out of both to the north, that the deposits of this group must have had one great source of supply somewhere to the south. The quartzites of Naggery, Narnaveram, and Tripetty hills are of enormous thickness and very coarse; while even the limestones, in the valley north of Tripetty, are many of them most angular breccias.

Denuding forces were again brought to bear on the second group of deposits so formed; and then there was another filling in of a much larger sea with other sandstones and shales, and only local depositions of limestones.

Thickness of series enormous; 21,000 feet at the west.

Compared with that of the KARNÚL rocks, the thickness of the KADAPAHS is enormous. At the lowest calculation which the average lie of the beds will allow, the greatest present thickness amounts to 21,000 feet. This is calculated on a section running across the Gundycotta hills by the gorge of the Penn-air in a south-west—north-east direction, and so through Byrenconda hill station in the Nullamullays; but it must only be taken as an average calculation, for most of the sub-groups vary much in thickness along the fine outcrops displayed in the Nullamullays, and frequently show a tendency to thinning out, even in the middle of the field.

Faulting.

Taking the enormous area into account, as well as all the squeezing and folding to which the KADAPAHS have been exposed in their eastern portion, there has not been any very extensive dislocation, except along the eastern edge; and here it is not at all clear that the close juxtaposition of the newer strata against the gneiss is always indicative of faults. The term 'close juxtaposition' is used, because it is only here and there along the whole line that the gneiss and the newer metamorphics have been traced into absolute contact, owing to the great talus of debris fringing the base of this part of the eastern ghâts. However, in almost every case where these rocks have been observed at such contacts, it was found that the quartzites were dipping at the gneiss at very high angles; in which cases there can be no reasonable doubt of faulting, especially when it is the fact that at the same time these quartzites which are butting against the gneiss are of enormous thickness, and are (except in the northern part of the Yellacondas) overlying the Cumbum beds, which are of the third group.

Space beneath the eastern talus for concealed natural boundaries.

There is indeed very often room enough under the talus for a turning up of the beds; but this cannot be the case all along the Yellacondas, considering that the strike of the beds runs, particularly in the

southern part of the range, right at the gneiss. Nor again, in the northern part of the same range, which was more particularly surveyed by Mr. Foote, can the talus there be always brought forward as a shelter for what, if there were no faulting, would be a very sudden thinning out of the great Cumbum group, which in that part of the country overlies the quartzites of the mountains.

Abruptness of boundary not always due to faulting.

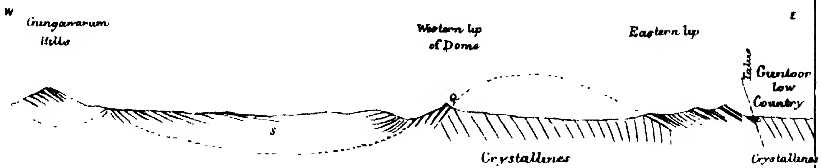
In the long section taken across the country, it will be seen how the different groups are thinning out to the north; the *Kistnah beds* which are higher than the Cumbums becoming there bottom beds on the gneiss. Now, if the northern end of this section were crushed up and folded against the country to the south, there might be presented the feature of a tremendous series of quartzites apparently resting on the Cumbum slates and in abrupt contact against the gneiss at the boundary. In such case there need have been no faulting, always provided the thrust were horizontal, and that the strata were capable of being folded back on each other without fracture, as they have been in many cases now displayed in the country.

It is very possible then that a good deal of the abruptness of the eastern boundary may be due to such a set of conditions as that just cited: there are undulations in the 'domes,' foldings in the Nullamullays, and inversions in the northern part of the Yellacondas and in the Waumyconda and Palnád area—the folding of the curves and inversions generally being to the westward; all of which show that the crushing up referred to in the conditions supposed in the last paragraphs must have occurred. At the same time, too, there is very good evidence over the north-east part of the field that the groups there developed are thinning out over lower groups, just as they now do, without showing any folding over the northern edge of the country.

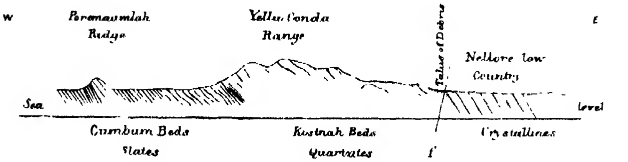
Sections showing abruptness of boundary.

A series of cross-sections of the eastern boundary may, perhaps, best illustrate its abrupt and seemingly faulted character; they are taken where the talus below

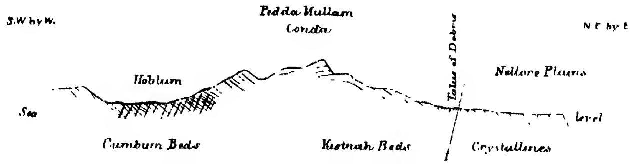
Horizontal Scale 4. Miles - 1 Inch Vertical Scale 6000 Feet - 1. Inch



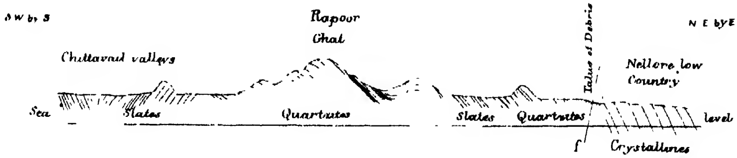
Section 5 Through Gungawarum hills and the Vinuconda "Dome", shewing easy undulations though with a steeper fold to the westward S Cumbum beds Q ? Nullamullay Quartzites



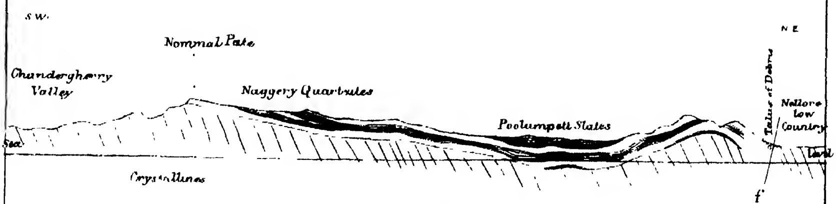
Section 4. Western extremity of section 5 taken across the Yelluconda range Showing abrupt E Boundary



Section 3 Across the Yelluconda, north of Pennair Showing abrupt boundary



Section 2 Across the Yelluconda by the Rapur Ghat



Section 1 Across the south by Tripetty Hills

the Yellacondas is tolerably wide (Plate V, Figs. 1-5). And, in like manner, the other lines of faulting shown in the map along this side of the country, have been introduced where no conceivable natural lie of the rocks can be brought forward to account for such an abrupt juxtaposition.

Mr. Foote's notes on eastern edge of field.

Mr. Foote considers that most of the eastern boundary, so far as he examined it, * is faulted,—a much more decided view than that of Mr. Charles Oldham or myself regarding the rest of the same boundary to the south; on this account, it is better to give Mr. Foote's own description of that part of the country:—

"The great fault which divides the KADAPAH rocks from the older gneissic series in the Nellore country along the east base of the Yellaconda range, was, in all probability, formed prior to the great period of denudation, which gave to the country a shape not far different from that it now possesses. It was accompanied by a great upthrow on its eastern side, the true basement-beds† of the KADAPAH series being exposed in several outliers. In these the lowest beds are seen raised to levels equal to those occupied by the middle or upper members of the series at the nearest points in the adjacent mountains (Yellacondas). This is particularly well seen in the great outliers capping the mountain mass twelve miles north of Oodagherry, and locally known as the Byrawoodiconda; the contrasting relations of the strata in the outlier and in the main ridge of the Yellaconda being exhibited."

These remarks were written with reference to about the middle portion of the range, but the further northern extension is again referred to as follows:—

"The principal line of boundary appears to be formed from end to end by a succession of faults which upraised the older gneiss rocks. On the east side the upraised gneiss region appears to have undergone most tremendous denudation and to have had the once superincumbent series of rocks, many hundreds and possibly many thousands of feet in thickness, removed from its surface *in toto*, and besides that, to have been itself planed away to a great extent."

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* The whole extent, from 15° N. Lat. up to and beyond the Kistnah, with the exception of some trifling spaces subsequently examined by Mr. C. Æ. Oldham.

† It is not so clear that these are the true basement-beds; possibly they are Byrencondas and outliers of the same beds in the northern part of the Yellacondas.—W. K.

Other and cross faults.

Associated with this main north and south line of faults are many others which cross them at various angles, principally in north-north-west and north-west lines, and occasionally nearly east to west; but these become excessively obscure as soon as they are tracked to the strata inside of the eastern boundary. Indeed, they are, for the most part, only recognizable by apparent disconnexion and displacement of recognizable bands of strata.

The Goolcheroo faults.

In addition to these dislocations of the country on the eastern side, there are others which are much more plainly seen. To the south-west and west-south-west of Cuddapah town, there have been some well marked displacements in the strata of the lowest group along nearly east-west and north-west—south-east lines. In this case, there was a stepping series of upthrows to the northward. By this series of faults, the continuity of the *Paupugnee beds* was broken over the flat bay of country south of Cuddapah. There are also traces of great squeezing and dislocation in the narrow gully between Bankrapettconda and Pollconda to the east-south-east of Cuddapah.

On the Chey-air.

Down at the Chey-air, in the mass of hills, on the left bank of the river to the east of Nundaloor, there is another area of sharp undulation and possible fracture by which the quartzites of the *Nullamullay group* are not now recognizable in any strength on the right bank of the river. Very possibly, this may be, in great part, due to sharp folding and subsequent denudation.

East side of Khoond-air valley.

The remaining faults, or series of these, are traceable by a sharp turning up, and then inversion, of the KADAPAHS, over KARNÚLS along the eastern side of the Khoond-air valley,—possibly an extension of the Pollconda area of squeezing and fracture. The features accompanying this line of dislocation die out to the north. Near Nundiallumpett, there are traces of an east and west cross fault, having a downthrow to the north.

At the southern end of the field there has also been some faulting, though here too the line is obscured by debris and alluvial deposits. The fault commences between Tripetty and Curcumbode, and is seen thence to increase eastwards, for, in the hills above Tripetty, the bottom or Naggery beds are seen, lying naturally on the gneiss, whereas, towards the eastward, the same and higher beds are right down in the plains, and in close proximity to the gneiss, with all the signs of an abrupt junction. The southerly and south-easterly outlying Batanaicconda, Narnaveram, and 'Naggery Nose' hills are all capped with the bottom beds at a good elevation.

Curcumbode fault.

The outlying ridge of quartzites running up from the Batanaicconda to Calastry town on the Soornamookey is faulted for a short distance along the western side and at the northern extremity; but there is no means of tracing these dislocations into those of the southern end of the field owing to the alluvial flat of the river covering up everything, though the end fault at Calastry seems to be a continuation of the Curcumbode fault.

Calastry ridge.

Again, in the Palnád, the limestones are, over the eastern half of the field, very much cleaved, and so situated that they appear to be overlaid by the quartzites of the eastern ridges. The easterly and westerly cross faults of this part of the eastern boundary seem likewise to have been continued in among the limestones of the Palnád, for there are certainly breaks in the continuity of the bands of limestone and an intermediate seam of slates to the east of Piddoogooralla.

Faulting in the Palnád.

Little can be said regarding the relative age of these various systems of faults, except that they are younger than the KARNÚL ROCKS. In two parts of the field, some of the crushing and accompanying faulting was transmitted to the newer formation. On the eastern side of the Khoond-air valley, over its southern half at least, the *Khoond-airs* and *Jummulmudgoos*

Some of faults younger than KARNÚLS.

are more or less cleaved into slates, this structure being strongest along the base of the Nullamullays, where also there is much disturbance evident in the quartzites, limestones, &c., of the older rocks.

General character slaty.

One of the most marked characteristics of this formation is the prevalence of cleavage throughout the greater extent of the rocks. This structure is naturally best seen in the clay slates; it is next best exhibited in some of the limestones, and least in the quartzites.

The strike of the planes of cleavage is very constant in its direction, seldom varying more than a few degrees, and it generally runs N. 3° W., N. 10° W., or N. 15° W., though oftener N. 10° W. In the north-eastern on Markapoor part of the country, the direction becomes east of north, until in the Palnád, it is nearly north-east—south-west.* The dip of the planes is generally to the eastward at 30° or 60°; occasionally it is vertical, and very rarely it is to the westward. These planes are often curved or slightly undulating, the interstitial partings having been subsequently, in many instances, filled in with quartz; while the slates are very talcose and chloritic.

The following figures and observations are illustrative of this. Fig. 18*a* is of a section occurring on the eastern flanks of the Nullamullays, north-west of Sevashettypully, among dark green and rusty brown talcose and chloritic slates, which are curved in their bedding and highly impregnated with quartz in the planes of cleavage. The letters *(a, a, a)* indicate edges of stratification nearly obliterated; *(b, b, b)* edges of undulating cleavage planes showing the interstitial quartz. Again, west of the above-mentioned village, there are light grey slates much impregnated with quartz. Ordinarily the cleavage is N. 5° W., dip 30° to 40° eastwards; but as soon as undulating

* In this there is a remarkable parallelism with the average strike of the strata.

cleavage planes are seen rolling about very much, now dipping east or west, and presently vertical, tnere the associated quartz is found. So that the deposition of the quartz would seem to be an accompaniment in some way of the formation of curved cleavage. At the same time, the bedding is at various angles westward; and its surfaces are frequently puckered in sinuous ridges and furrows.

Likewise, on the Jungumrazpilly pass across the Nullamullays, (Fig. 18*b*), there are grey slates in which the planes of cleavage are undulating with a general dip of 30° to 35° eastward, strike of planes N. 3° W., surface of planes slightly rugose or puckered up in sinuous lenticular elevations and depressions.

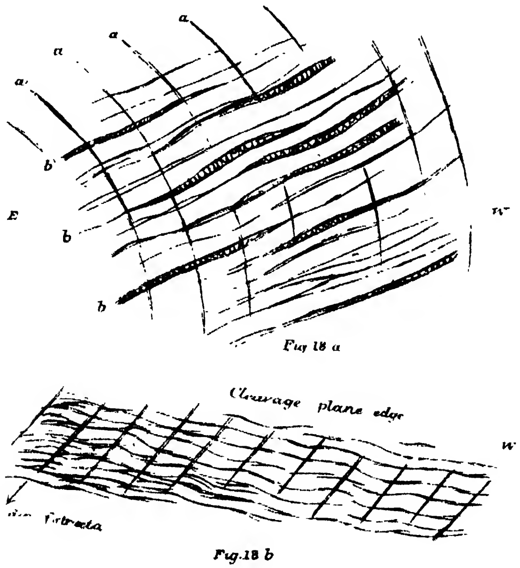

Fig. 18. (*a*) (*b*). Wavy cleavage-planes.

The varying amount of cleavage in differently constituted but adjacent bands of rock is often very well displayed.—First, locally, as in the case of a series of limestone and talcose strata: near Mootakoola* beds of this kind occur. The planes of cleavage have an undulatory course which is clearer and more tortuous in their passage through the talcose bands, as in the annexed diagram (Fig. 19).

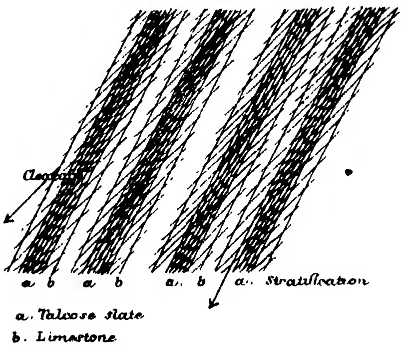

Fig. 19. Cleavage varies in amount in rocks of different composition.

In the next two figures, the same feature is illustrated over a good extent of country. Fig. 20*a* is a diagrammatic section across part of the Nullamullays at the northern end of Jundermorum tank, where clay-slates *(c)* rest on calcareous slates *(b)* and these again on silicious limestone *(a)*. The slates are highly cleaved, with planes dipping 30° E. by N., while the calcareous slates are cleaved to a much less extent; the limestone at the bottom of all being entirely devoid of this structure. The next illustration (Fig. 20*b*) shows variation in the inclination of the cleavage planes: it is also from the Nullamullays, this section being taken in a nearly westerly direction from Jungamaraypilly to the valley which runs southwards to Yellacoopa.

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* In the north-east part of the country, 16 miles west-north-west of Vinnaconda.

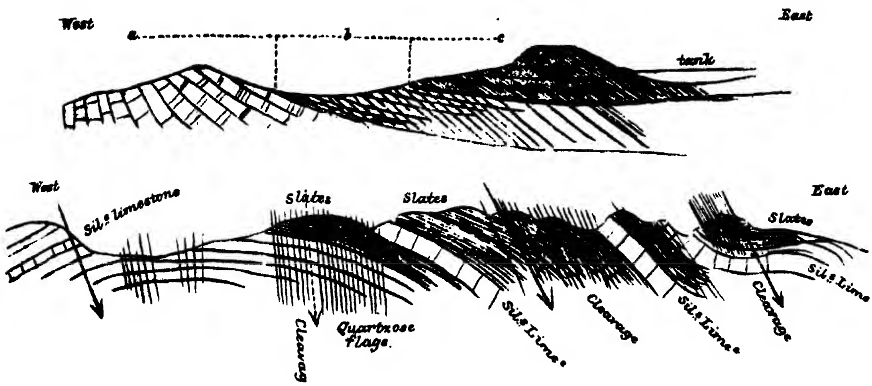


Fig. 20, *a* and *b*. Sections showing the variation in cleavage in the Nullamullays.

Though the rocks are so well cleaved, there is not any instance of such perfect slates as the typical roofing slate of commerce. They are not sufficiently indurated for this, or if they happen to be hard or compact, they are so coarse in their texture that cleavage is not well developed in them. Generally, the cleaved rocks are moderately dull lustred clay-slates of dark grey, greenish, blue, and purple colors; but there are many examples of talcose slates of pale grey and green colors. Occasionally, as along the western slopes of the Yellacondas and the inner ridge of hills, there are some bands of dark green, weathering rusty brown, chloritic and talcose slates.

The best slates, or such as seem capable of being worked into slabs of any moderate size and thinness, are near the upper Hoblum pagoda, high up on the Nundycunnama pass;* and on the middle ridge running north from Kullsapaud.† Slates are quarried, to some little extent, on the eastern flanks of the Nullamullays at about the parallel of

* Principal cart road across the Nullamullays from Nundial to Cumbum.

† East side of Nullamullays, 32 miles south-south-west of Cumbum.

Dhoor. As a general rule, however, there is no approach to the slate of commerce; the closest approach being only as flags or thick slabs. They cannot be chipped into blocks of any good size or shape, except with great care; jointing being almost as well developed as cleavage, except in the less frequency and closeness of the planes of division. In hammering most of the slates they may just as readily split along a plane of jointing (though not apparent to the eye) as along cleavage planes. Fracture always takes place by planes of cleavage or jointing; very seldom along those of lamination. It is often extremely difficult to recognize lamination: occasionally utterly impossible, except by reference to the adjacent beds of quartzite.

One of the groups (Cumbum slates), or rather a band in this group, is very largely mixed with quartz; but it is very difficult to say decidedly in what planes,—occasionally in those of cleavage, and again in those of bedding. In the southern part of the Nullamullay region, as along the Budvail valleys of the Cuddapah district, the quartz was apparently always in the planes of cleavage; but north of this, between Poremaumla and Cumbum, the interlaminar spaces are charged with this mineral.

General character of quartzites.

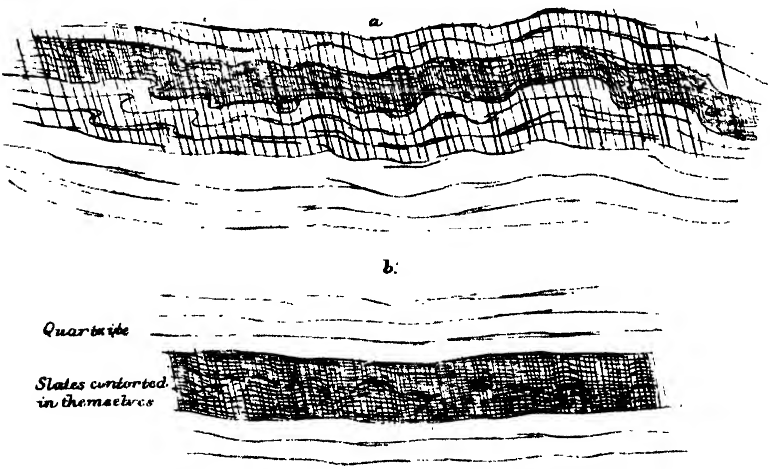
The quartzites in all the groups of the KADAPAH series are, to all appearance, as a general rule, altered sandstones and grits, being only conglomeratic to any marked extent in the lower groups. This appearance may deceive, as in a marked example, on the flanks of the hills north-east of Cuddapah, of a quartzite which, if it were not for weathered surfaces, might be taken for a uniform granular rock, whereas, in weathered masses, it is an exceedingly coarse conglomerate. Sufficient weathering, therefore, may not have been superinduced upon those homogeneous-looking beds of the other groups to bring back to light their original constitution. Still, there are frequent cases of complete weathering without any result but a true sandstone or grit: consequently, this character may be almost safely

given, though it is as yet only negative, that the quartzites of the Nullamullays and their southerly extension are generally only grits and sands, except in one or two groups.

This, to a certain extent, indicates that the rocks of the eastern side of the field are well up in the series, as independently inferred from the sections; though, here again, there is an exception in the Eeshwarnacoopum mountain, in the northern part of the range, where sandstone beds, not conglomeratic, are very low, or even of the lowest, in the series.

Cleavage has been at times very distinctly superinduced in the quartzites, more particularly where the strata are much contorted and reduplicated; and, perhaps, there is hardly anything more indicative than these instances that cleavage is the effect of pressure at right angles to the resultant planes. The quartzites are very seldom strongly cleaved until they are sharply contorted or crushed up in themselves, in the same way as is often the case with the slates.

The following diagrams will show what is meant by the expression 'beds being crushed up in themselves.'



Figs. 21a and b. Beds contorted in themselves.

Fig. 21*a* shows the frequent case of a band of slates being contorted in themselves, while the adjacent beds of quartzites are not at all so sharply folded. In such case, cleavage is only to be seen in the slates. Fig. 21*b* showing the rarer cases of quartzites contorted in themselves. In cases of quartzites being contorted in themselves, it always appeared as if the force exerted had been a quick, jarring one, so that the beds were crushed up in steps, and were not much moved out of the general plane in which they lay before the force was exerted: In such cases, the cleavage was more decided at these points of jerking.

Such examples of cleavage of quartzites are very plain in the hilly ridges striking southwards from Giddaloor (east of the Nullamullays) to Kullsapaud. The northern ends of these ridges are well cleaved.

Cleavage of quartzite merely produces thin slabs.

Cleavage in the quartzites does not produce anything in the way of a slate of quartzite for instance; but it gives tolerably thin slabs of rock and flags. By the same force, there are also flags of slate.*

The cleaved slabs of quartzites are from a quarter of an inch to two or three inches in thickness, and are often quite large enough for flooring or roofing houses.

There is an intermediate form of rock between slates and quartzites, which is often met with over the Nullamullay country: and this may be called quartzose slates or slaty quartzite, according as the sandy or clayey element is most persistent; but these terms are only used where cleavage is prevalent. The rock is generally of a grey or greenish color, and quartzose. There are plenty of quartzite flags of the same appearance in the Nullamullay country, but these split up in lamination,

* Properly speaking, the term 'flag' ought only to be applied to thin beds of rock, or to slabs split off along planes of deposition, so that other flags might be distinguished by the term slaty flags or cleavage flags, where large slabs of rock are so produced. When, therefore, the terms 'flaggy quartzites' or limestones are used in this report, it must be understood that thin bedded varieties of the rocks are referred to.

and are not sufficiently cleaved to split in other planes than those of deposition. The long ridge of hills just inside the Yellaconda, and stretching northwards from the Budvail ridge of the Cuddapah district past Poremaumla, is largely made up of flaggy quartzites; while, on the other hand, the western flank of the northern end of Rajpolliam ridge (about twelve miles south-south-west of Cumbum), is almost entirely of quartzose slates, or slaty quartzites.

Slates and quartzite bands suggest natural grouping of zones.

One reason for separating this series into so many groups of sands and slates is the fact that it, especially in the Nullamullays, is made up generally of such distinct bands of quartzites and slates. The lower groups, as they are developed along the western side of the area, are very easily settled; for here there are groups of strata which are distinctly separated by overlap and unconformity.

In the Nullamullays, there are no other strata but those of quartzite and slates, and, consequently, it is very difficult to recognize the same bands again if there be anything of a large gap in the continuity of their outcrop. This outcrop is fortunately tolerably clear along the slopes of the mountains, so that the boundaries are followed out without much difficulty.

It must not be understood, however, that the different bands of quartzite and slate are made up simply of these different rocks; only that they are more slaty in their general character, or more of quartzites. There are bands of quartzite beds in the slate groups, and *vice versâ;* and, perhaps, as a general rule, the quartzite groups contain finer and thinner bands of slates than the slates do of quartzites. It is also not unfrequent that, as the different groups are traced out, they sometimes lose their distinctive character as of one kind of rock or the other, quartzites being replaced by slates; though, perhaps, it would be nearer the truth to suppose that a group has thinned out altogether at times.

It is this thinning out or replacement which renders the northern part of the area towards the Kistnah so obscure in the correlation of its strata, there being no such distinct succession of beds as occurs around Cumbum for instance.

KADAPAH rocks mineral producing.

The KADAPAH ROCKS are the main store-houses of what mineral wealth there is in this part of the country. Iron ore occurs in nearly all the groups, particularly among the quartzites. Copper ore was worked in old times in the western representative of the Cumbum group, and again in some of the quartzites of the next lower group, or possibly of the same series; while lead was extensively mined in the Mogul days in the same group.

Further notices of these will be given in the chapter on the industrial resources of these districts.

Difficulty in describing KADAPAHS in descending order.

It would be well if the KADAPAHS could be described in the same way as the KARNÚLS, namely, in descending order; but this cannot be done so conveniently as with the newer formation. There are so many breaks in the continuity of bands of strata, and so large an area is concealed by the KARNÚLS, that, in a descending examination of the groups, continual reference to the most permanent outcrops is necessitated, which outcrops are about the lowest in the series; while the frequent repetition of reasons for considering subjacent groups as equivalent in different parts of the field, would only weary the reader.

Even though the lower groups are the most continuously traceable, yet, as will be shown, with these also there is much obscurity, though not so much as exists among the other groups.

An apparent triple grouping in parts of the field.

A three-fold division of the formation is very apparent at different parts of the field; but it is not at all clear that each sub-group in these regions is always the same. For example, in the Cumbum country, there is a fine succession of strata exposed in any easterly traverse from

the centre of the Eeshwarnacoopum mountain.* This mountain forms a nucleus of quartzites with slate bands, or lowest sub-group, round which there is a circling band of quartzites and slates, or middle group; outside of which, again, is another series of quartzites and slates, on the last of which the town of Cumbum stands. But this arrangement, though very closely, is not perfectly, traceable into another grouping of strata further north in that part of the Nullamullays which is traversed by the Kistnah. So, in like manner, there is a triple grouping of quartzites and slates on either side of the meridian of Cuddapah, but there is a want of resemblance in the sub-groups, and their continuity is concealed by more recent deposits.

Fourth group.

There is a fourth or higher group of rocks in the Kistnah Nullamullays and in part of the Yellaconda range; but its relations are not at all so clear as those of the triple division.

Series to be described in ascending order.

Seeing, then, this uncertainty as to which may be the highest group of the series, it is fit to begin with what are visibly the lowest, or that group which rests on the crystalline rocks, and under which none other appears in any part of the field.

Fundamental beds apparently along the whole of western edge of field.

Strata of such a fundamental group are found on the western or Bellary side of the field; and, to all appearance, the long continuous scarp extending from the Tripetty hills right up to Juggernatconda† seems to be of one and the same group of quartzite sands and conglomerates.

Scarp beds of southern half.

Mr. Charles Æ. Oldham traced this scarp northwards from Tripetty, to well beyond the Paupugnee river, finding it to consist of a thick series of sands and slates, which is regularly overlaid by another series of slates in the broad Chey-air valley to the eastward, until, in the neighbourhood of the passages of the

* N. E. of Cumbum, from 3,000 to 3,500 feet above the sea.

† A few miles south of Kurnool.

Chey-air and its tributary, the Chitt-air, his observations showed that other and lower bands of slates and sands were very gradually tailing in from the north.

Overlap scarp beds of northern half.

I subsequently followed out the western scarp rocks and the deposits above them, finding, likewise, from Kurnool southwards, that the lowest beds are sands and conglomerates, with, however, a not very decided band of slates; over these comes a very continuous and well-marked series of slates with limestones, to some extent rather like the slate series which Mr. Oldham traced above the southern quartzites, or, as he used to denominate them, the 'Naggery quartzites.'

Near Goolcheroo, south of Cuddapah.

But, to the south of Cuddapah, this so well-marked series of limestone-slates of the Paupugnee river valley disappears quite suddenly, partly by faulting, partly by being covered up by a superincumbent unconformable series of quartzites, and by thinning out. At any rate, they thin out along the base of the northern slopes of the Goolcheroo hills; and they cannot, on any view of faulting or undulation of strata, as far as is at present known, be supposed to be represented by the limestone-slate band further eastward under the Pollconda hill,* which is continuous into the slate series of the Chey-air valley.

Indeed, Mr. Oldham shows by his notes that there are representatives along the hills north of the Chitt-air, of slate and quartzite bands which I have seen on the western slopes of Pollconda and in the flat Bogroo (Booggoo) valley south of Cuddapah, which are not associated with the quartzites of the Goolcheroo hills.

Goolcheroo quartzites, lowest beds.

So far there is good reason to suppose that the Goolcheroo quartzites and the slates above them are not representative of the Naggery quartzites to the south and their superincumbent slates, but that the Naggery quartzites

* South-east of Cuddapah town.

are those which are overlying the Paupugnee limestones south-west of Cuddapah.

There are, however, some features against this: the Paupugnee band of slates is overlaid quite unconformably by this band, the lowest beds being of conglomerate and breccia, made up of the debris of the subjacent strata; but these cease to the south of Cuddapah, and there is no unconformity visible in the hilly country further southwards, traversed by the Chitt-air and Chey-air. The basal conglomerates and breccias of Goolcheroo may certainly have died out to the east, while the thick upper sandstones and grits of the same band were eventually spread out beyond the Goolcheroo beds on to the CRYSTALLINES, and are thus the bottom beds for the southern portion of the western scarps.

Points against this view.

Again, the strata seen south of Cuddapah between the conglomerates of the low hills south-west of Chintakonadinna and Pollconda, are very far from resembling the strata above the quartzites on the left bank of the Paupugnee, except in the presence of limestone bands. Still, these changes of characters in strata are not impossible; and it is very probable that only a small portion of the slate group under Pollconda is there visible; for the quartzites capping this hill are unconformable on the subjacent beds.

There is, besides, a great deal more of the strata above or north of the quartzites on the left bank of the Paupugnee obscured by superficial deposits, than of the strata of the Chey-air valley, and this alone, without taking into account the presence of volcanic deposits in the former area, would hinder any recognition of general resemblance between the two.

It is to be confessed that, on the face of the map, and even from the appearance of the rocks and of the country, the long outcrop of lowest beds from Tripetty to Kurnool is very like that of one series; but it is impossible to get over the fact of the Paupugnee limestones dying out

east of Goolcheroo, and of bands of slates gradually thinning out under the quartzites to the south-east, which are traceable into strata further north clearly overlying these limestones.

Present classification of series mainly tentative.

At best, however, without any palæontological evidence, and whilst the continuity of the rocks is so frequently obscured, the classification adopted by us must, to a great extent, be considered as tentative.

It is possible, too, that the rocks, whether Naggerys, or Goolcheroos, are not the oldest of the series. The lowest rocks of Eeshwarnacoopum are not exposed; and there are outliers along the eastern boundary of the field which are bottom rocks for that region, and yet are untraceable into, or unrecognizable with, other bottom beds within the field. The strata—quartzites with bands of slate—of the main mass of Eeshwarnacoopum belong, if the succession of groups be correct throughout the field, to the lowest of the series, or the *Paupugnee* beds; while the thin belt of quartzites of Soonkasla Peak,* and the band of Urdaveed, or Bolapilly, slates above them, would be *Chey-air* beds.

CHAPTER 2.—THE PAUPUGNEE BEDS.

Goolcheroo Quartzites.

Lowest group of KADAPAHS best seen on the Paupugnee.

This group is best displayed along so much of the valley of the Paupugnee river as traverses the area of the KADAPAH rocks; though this is only a very small portion of the outcrop, extending, as it does, in a belt of generally some ten miles in width right up to and beyond Kurnool.

A set of quartzites overlaid by slates with limestones.

The series is made up of a set of quartzites which form the fringing scarp and eastern slopes of the western hills from about Goolcheroo† to Lorepoor‡ on the

* North-east corner of Eeshwarnacoopum range.

† Fifteen miles south-south-west of Cuddapah.

‡ Suburb of Kurnool.

Toongabudra, and a thick sub-group of slates and limestones, of which the bottom of the long valley behind the scarp is made up.

Character of Goolcheroos.

The quartzites are essentially sands and grits with bands of conglomerate and pebble beds: while there are intercalated sandy shales, flags and slates of variable thickness. The strata are lying for the most part tolerably easily on what must have been an undulating, or not very roughly denuded, floor of granitoid gneiss; and so the boundary, from Goolcheroo northwards, is a natural one except for a short distance near Ramulkota* where the hitherto regular outcrop is broken and displaced by the Gunnygull line of fault.

This boundary line between the Goolcheroo quartzites and the CRYSTALLINES lies nearly the whole way to within a few miles of Kurnool, along the bottom of a more or less cliffy scarp below which is the rough slope of the older rocks. The exceptions to a scarped outline are naturally at the passages of the different rivers, of which there are five,† through the western hills.

The cliffs of the scarp are grandest between the Paupugnee and Goolcheroo, where they must attain a height of two hundred feet; but they soon dwindle down to 60 or 70 feet as they are followed west and north, and are then often a mere step of 8 or 10 feet, as Kurnool is neared.

There is some evidence that the lowest beds of this sub-group along the northern part of this outcrop, or from Poopalla‡ northwards, has been to a certain extent altered along with the subjacent CRYSTALLINES. Or, in other words, they have apparently been baked, or cemented into one mass with the granitoid rock in contact with them.

The lower beds are generally exceedingly coarse conglomerates which are often full of pebbles and shingle of red and black jaspers, the

* Eighteen miles south by west of Kurnool.

† Chey-air, Chitt-air, Paupugnee, Chittravutty, and Penn-air.

‡ Four miles north of the passage of the Penn-air.

dark bands of which are of hæmatite. These jasper-loaded conglomerates are strongest between the Paupugnee and Penn-air.

Another very marked and exceedingly coarse form of conglomerate, which is, however, very local, is made up of debris of brecciated quartz-rock which was evidently derived from the denudation of the runs of 'fault rock'* so common just outside the scarp in the granitoid rocks. The resemblance to the parent rock is great, and the closeness of the coarsest debris to great walls or ridges of this fault-rock leaves no doubt in the mind of the observer as to the sources of the conglomerate fragments.

Character of group best illustrated by details.

Little more than a general idea of this lowest group can thus be given; but there are features of interest at certain points along the outcrop which can be illustrated best by selections from our notes, and which may serve the future explorer much better than what could be given in a general sketch.

Mr. C. Æ. Oldham's work, north from Goolcheroo.

Taking the group at its southern end, near Goolcheroo, Mr. Charles Oldham notes that—

Bottom or contact beds.

"North-west of Wungymulla† there are 100 to 120 feet or more of a grey and purplish, intensely hard quartzite, rather coarse and thickly bedded, resting on the denuded surface of the gneiss. Over this some thinner and more flaggy beds. In the river gorge east of Wungymulla the lowest beds seen, not in actual contact however, with the metamorphic rocks are purplish colored, hard slaty beds, with some massive reddish quartzites, over these a succession of thick beds of grey quartzite with ferruginous bands.

Traces of a higher series coming in.

"East north-east of Wungymulla, greenish-grey and purple quartzites form the mass of the face of the hill, while there are some flaggy and slaty beds above: these form the plateau above and are capped by hard grey quartzite.‡

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* These walls of fault-rock often run right up to the scarp and are evidently continued under the KADAPAHS. In one or two instances the dislocation of the KADAPAHS is with these runs.

† On the left bank of the Chitt-air.

‡ These are of the next group of Naggery beds, and correspond to the quartzites above the limestones on the left bank of the Paupugnee.—W. K.

"Near Goolcheroo the surface of the gneiss, which here is highly syenitoid and considerably disintegrated, is covered by coarse purplish ferruginous quartzites, with occasionally thin slaty beds. Over this, massive thick-bedded quartzite which forms the mass of the hill, and, with some hard purple slates overlying it, composes the sloping surface of the hill northwards. The general slope of the hill northwards is about the same as the dip of the beds.

"Again, north-west of Goolcheroo, thick massive beds (quartzite) at bottom (the actual junction with the gneiss, which is seen close by, being obscured by debris); then about 20 feet of thinner-bedded, somewhat flaggy strata. Over these, coarse false-bedded quartzites forming the mass of the upper part of the hill, 2 to 300 feet, with some purplish slaty beds* overlying them and stretching northwards down the slopes of the hills. Similar beds are seen on all the spurs of the ranges east and south-east of Goolcheroo.

"Nulkoorty peak,† one of the highest, if not the highest point of this part of the range, shows fine cliffs of purple and yellowish quartzite in thick massive beds very similar to those seen near Goolcheroo. In the valley north of Nulkoorty purple slaty beds are seen."

Faulted valley north of Nulkoorty peak.

With these purple slaty beds in other parts of this long east-west faulted valley are bands of limestone: and these beds are the same as those further west in the Paupugnee. The middle of this valley except for a few miles at either end is of granitoid gneiss traversed by trap dykes: and on the northern side there is a second line of bold and precipitous cliffs of hard grey quartzite which are the same as those in the outer Nulkoorty scarp. There has been a downthrow to the south of from 3 to 400 feet along a series of faults by which the gneiss is thus brought in, in sharp contact with quartzites and limestones. This system of faults dies away at the eastern end of the valley, until the edges of the quartzite on either side of the fault are brought into contact again. Before the dislocation took place, the Goolcheroo quartzites must originally have lain in a great roll over a hill in the Cuddapah gulf which thus gave the Nulkoorty peak elevation, for there is a cross watershed in the middle of the range whence the streams flow away east and west.

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* These are the dying out traces of the superincumbent limestone slate series.—W. K.

† 3,030 feet; southward of Cuddapah.

"On Dekundraian peak are coarse ferruginous quartzites with bands of conglomerate. North of Cotapait rock similar beds form bold bluffs.

Section at the Paupugnee pass.

"At the Paupugnee, south of Vaimpully, a good section is obtained in the river gorge which in ascending order is as follows:—coarse, rather ferruginous quartzites much false bedded, the lowest parts obscured by a talus of fragments, often of enormous size. Over this a hard greyish quartzite (with some more slaty and flaggy partings) forming bold bluffs or cliffs along each side of the river, of 200 feet or more, and having a low rolling dip to north by west or north. Over these on the north, a succession of silicious flags, indurated clays, and beds of impure limestone.*

Goolcheroos decreasing in thickness.

"South-east of Vaimla ascending from Vapatmonpait to Meedpenta, under the indurated shales and calcareous slates, come coarse grey quartzites with conglomerate bands, ferruginous. Again, north of Goondoowarpully and Bolagootacheroo, there are similar beds forming the top of the range, but a less thickness of the coarser pebbly quartzites; the gneiss appearing nearer the top of the hills and the more flaggy and slaty beds coming in nearer to it.

"Again, south-west of Vaimla resting on the gneiss, coarse conglomeratic quartzites; and over these hard thick-bedded and coarse massive quartzites with ferruginous flags.

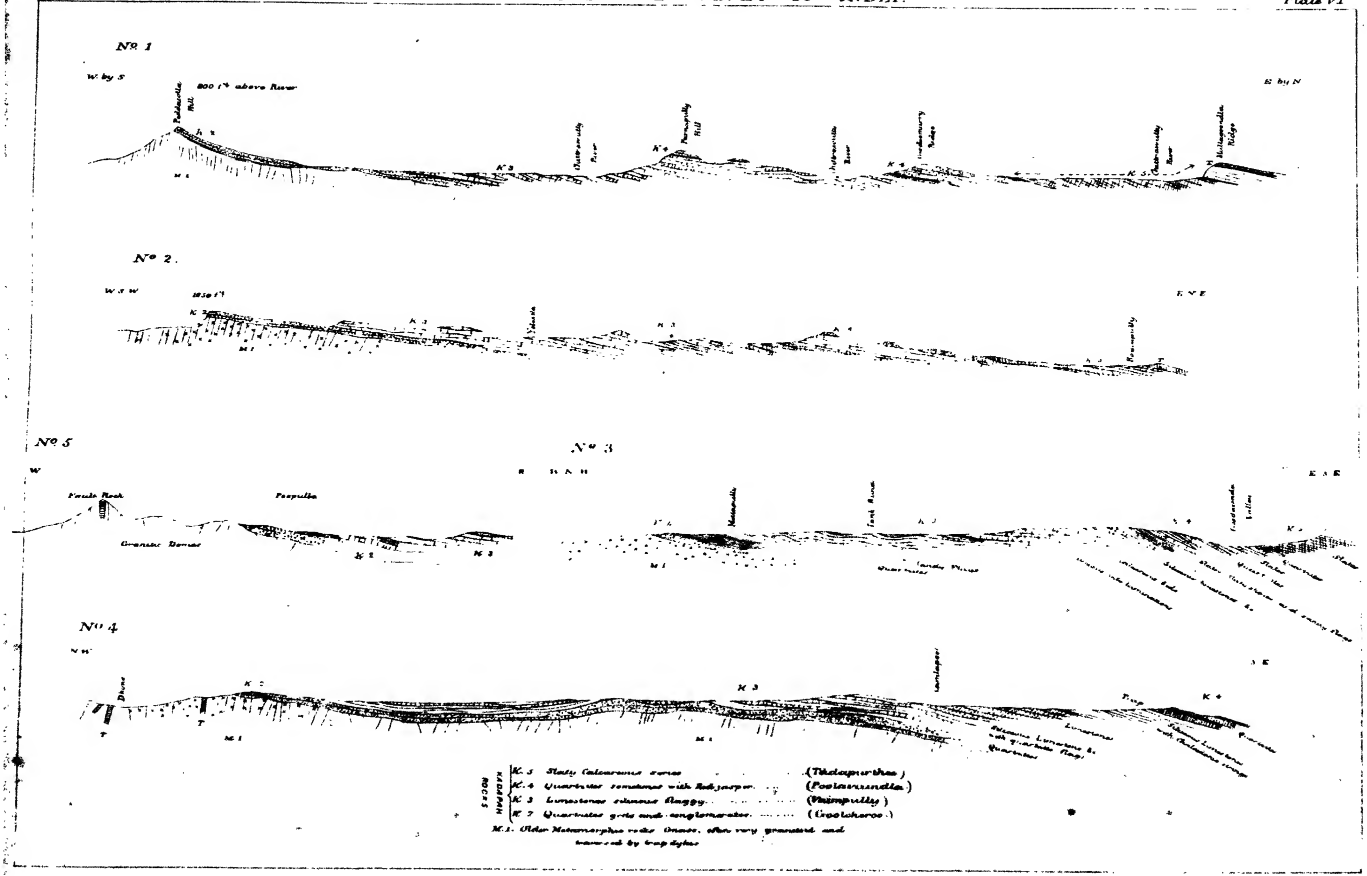
Rippled beds.

"South-west of Poolavaindla, above the gneiss in ascending order, the following series of rocks occurs:—a coarse gravelly quartzite at bottom, on this a conglomerate containing pebbles of quartz, flint,† and felspar. Over this a rather coarsely granular altered sandstone, grey and purplish, frequently much false-bedded, and ripple marked and often speckled by grains of felspar. Over this some ferruginous bands, with a sort of laterite conglomerate locally on the surface, and over these towards Goondaldeverpully a succession of finer quartzites, silicious flags, &c.

"North-east of Timmanainpolliam, on the extreme west of the Cuddapah Sheet of Indian Atlas, overlying the irregular denuded surface of a highly syenitoid gneiss, are greyish and reddish ferruginous quartzites with some conglomerates containing pebbles of quartz and of flint (? chert) rarely. The lowest beds are not conglomeratic, but are coarse ferruginous quartzite."

The following details are illustrative of such features of interest as are displayed by the Goolcheroo quartzites in their outcrop, from where Mr. Charles Oldham left them up to Kurnool; and the accompanying sections (Plate VI, Nos. 1, 2, 3, 4, 5,) show the manner in which these

* Beds of the upper sub-group or Vaimpully slates and limestones.—W. K.
† This is probably a pale grey flint-like chert.—W. K.


No. 1
W. by S
800 ft above River
E by N
No. 2.
W S W
E N E
No. 5
No. 3
No. 4
Granitic Domes
KADAPAH ROCKS
K. 5 Slaty Calcareous series
K. 4
K. 3
K. 2
M. 1. Older Metamorphic rocks

rocks are lying and their relations to the overlying Vaimpully slates and limestones.

Coarse bottom beds.

Near Dorragull* the Goolcheroos consist of about 150 feet of coarse quartzite grits and conglomerates in thick and massive beds, some of which are slightly ripple marked: all dipping at 10°-12° east-north-east or north-east down under the limestones, &c. Opposite the village, the scarp of quartzite cliffs is occasionally 100-150 feet high; but there is no scarp opposite Timmanainpolliam.

Pebble beds of jasper coming in.

Further north, from Comanootla (on Vaimpully beds) to Polleonda,† the surface of slope is nearly all one bed or set of beds of coarse obliquely-laminated and gritty quartzite, dip being 10° eastward. Near the crest of the hills there is a very coarse conglomerate, and then beds with layers of large fragments of dark-red, brown, purple, and grey jaspers and carnelians. At the crest the beds are very coarse and thick, 3 to 6 feet each. These are the bottom beds, resting on the older metamorphics. In the face of the scarp there are 70 to 100 feet of these beds.

Ribbon jasper.

Again, in the Chittravutty gorge, the bottom rocks are very coarse grey sandstones and conglomerates, the latter being full of large and small pebbles and rounded lumps of quartz, quartzite, and jasper. The jaspers are generally of deep red and black colors arranged in layers: the black bands being ferruginous and many of them highly metalliferous with specular iron ore. Some of the lumps of ribbon jasper are as large as a man's fist; and there are much larger rounded pieces of quartzite and coarse banded chert in the conglomerate. These lowest beds are not of any great thickness at this point, about 70 to 100 feet; but they are thick and massive of themselves.

Just south of this, opposite Boodanumpully, the lowest bed of the quartzites is about 2 feet thick, of reddish brown sandstone literally crowded with semi-rounded fragments (about the size of a walnut) of quartz, jasper, and quartzites of red, black, brown, and white colors. Then come about 10 or 12 feet of coarse grits obliquely laminated, in beds of 2 to 4 feet thick. These are of a dark, grey color. Above come very thick and massive strata of coarse grits, which are layered with large shingle and rubble, with intercalated thinner beds.

North-east of Peddakotla hill there is a gorge cut through the bottom beds by a tributary of the Chittravutty. The lowest beds are resting on quartziferous porphyry, and are of coarse, dark, purplish-brown quartzite grits and sands, with thick layers of ribbon jasper conglomerate. These layers are very distinct and mottled all over with white, black, and red pebbles, among which are occasionally coarse carnelians and onyxes.

* Eastern edge of Bellary district, three or four miles north-north-west of Timmanainpolliam (last locality referred to in preceding notes of Mr. Oldham), and south of the Chittravutty river.

† Not the Cuddapah Polleonda.

There are about 6 feet of flaggy and shaly quartzites (ferruginous) lying over about 10 feet of the lowest beds, and these are again overlaid by thick-bedded grits.

Section No. 1, Plate VI, applies to thus much of these beds.

Goolcheroos still thinning out.

Again, in the neighbourhood of Googood, the lowest of the Goolcheroos have thinned out somewhat, there being only about 4 feet of coarse quartzite grits and conglomerates with thick layers of jaspers. Above these comes a series of ferruginous, sandy and micaceous flags—the same as those in the gorge at the back of Peddakotla hill,—and again above these are more quartzite grits and conglomerates which dip down to the Nuddumdody valley, where they become covered up by calcareous shales and limestones (Vaimpully beds). Some of the ferruginous sandy flags are slightly ripple-marked and well laminated. The intermediate set of flags is about 20 feet in thickness, for a good distance along this part of the scarp.

Distinctive scarp ceases.

About four miles further north this hitherto distinctive scarp ceases, there being nothing but a very thin deposit of quartzite grits and conglomerates left lying on the granitoid gneiss.

Ridges of 'Fault-rock' in the CRYSTALLINES.

So far it has not been necessary to notice the fault-rock which is so conspicuous in the country below the scarp, as great ridges and walls of white rock for long distances; but as the lowest beds of the Goolcheroos are in this region often conglomerates of fragments of this fault-rock, it may be as well to treat of it here.

Opposite Kasaupully, a couple of miles south of Nuddumdody, there is a conspicuous and rugged ridge lying close alongside the boundary of KADAPAHS. This ridge belongs to and runs in the CRYSTALLINES in a north and south direction, with its wall-like back dipping about 70° west. It is made up of yellow and reddish jaspery quartz-rock (not quartzites) much stringed with white quartz in an irregular manner. There is also a good deal of brecciation displayed in nearly all the runs of this fault-rock. The interesting feature however, is, that, alongside this ridge the lowest of the quartzites are very coarse, dark, brownish-purple grits most thickly crowded with large angular fragments of, to all appearance, the very rock constituting the wall of the ridge.

Very coarse conglomerates of fault-rock.

In the neighbourhood of Coravypully, about four miles south of the Penn-air, the scarp is of thick-bedded grey grits, with just the faintest trace of breccia conglomerate of jasper, &c., at the bottom. Here there is a scarp of 13 to 20 feet.

North of the Penn-air, above Reddypully, there are reddish and purplish sandstones and sandy flags lying on coarse granitoid gneiss.

Section No. 2 illustrates the lie of the beds so far; but north of this a scarpless section is very common, as in Sections Nos. 3 & 4.

No scarp now: strata tail up the slopes.

In the neighbourhood of Poopalla (five or six miles north of the Penn-air), the features of the boundary change somewhat. Hitherto the bottom beds have run in a scarp overlooking a more or less steep and high slope along undulating hills and headlands, whereas now they are lying up the granite slopes which stretch down from the great ridge of fault-rock to the west. See Sections 3 & 4.

The bottom beds in this neighbourhood are mostly pale grey and dark-brown, or reddish grits and sands; while the lowest bed of all is a breccia and conglomerate of red and black ribbon jasper and quartz. Close to Poopalla the lowest bed becomes highly conglomeratic with jasper, quartz, quartzite, and quartz-rock (fault-rock) evidently from the adjacent ridge. There are no pebbles of gneiss, or granite.

Indication of alteration of junction rocks.

Hence northwards, the lowest strata present at intervals the appearance of having been cemented (possibly by infiltration), or baked or welded (by heat), to or with the subjacent CRYSTALLINES.

Bottom bed apparently baked into gneiss

Just north of Poopalla, the lowest of the Goolcheroos are the usual grits, much vitrified, and at one point apparently cemented or joined or baked into close contact with the granitoid gneiss. There is no clear line of junction between the two rocks: the bottom of the lowest stratum is one with the surface of gneiss: in fact, only for the decidedly gritty character of the laminæ it is difficult to say where the difference between quartzite and gneiss ceases. This lowest bed is, as is generally the case, conglomeratic in its lowest layers, and there are patches of the pebbly part still left along the boundary which are to all appearance part of the underlying rock, or baked into it. There is no doubt about this baked look all along from half a mile north of Poopalla to Beemanpully, about six miles. The lowest beds are more vitreous here than to the southwards.

Indications of old shingle bank.

At two points, *viz.*, about half a mile north of Chintalcheroo and in the low hill immediately south of Beemanpully, the lowest beds are most highly conglomeratic, for about 20 yards in the first instance and about 50 in the second. These localities look as though they had been points where rivers or torrents had once poured their gravelly and shingly deposits just on to the shore of the then sea, or they may have been shingle banks collected along the shore.

And so on at various points, with the general formation of sands, grits, and gravels, there were at intervals most enormously coarse conglomerates and breccias of this fault-rock, occurring locally in the neighbourhood of the runs which are now existent in the granite country outside of the KADAPAHS. And with the decrease of these walls or dykes of quartz rock, so the coarse breccias become fewer and fewer as the country is examined northwards. There is a splendid display of these features around the village of Uppaycherla which is close to the Cuddapah and Gooty high road.

The very coarse conglomerates decrease with the ridges of 'fault-rock.'

Again, still further north, between Goodypaud and the point where the Paipully and Banaganpilly road crosses these rocks, the bottom beds of quartzite conglomerates appear to be altered along with the jaspery quartzose gneiss underlying them. About here, the number of jaspers, &c., contained in the gravels and conglomerates decreases for a time. Opposite Paipully, or rather west of Chellumpully, the quartzites run up and nearly cap a high ridge, the crest of which is of fault-rock: and here there certainly seems to have been some alteration of the KADAPAHS and CRYSTALLINES. The quartzites have a very altered appearance, and they are stringed with white quartz in an east-west direction, in the same way as is the fault-rock on which they are lying.

Further cases of altered junction.

Not far south of this at the east-south-east end of the great Waunaconda ridge, there are what seem to be unmistakable evidences of a contemporaneous alteration of the older and newer rocks. Here, the conglomerates and breccias are overlying distinctly foliated jaspery gneiss, and the bottom bed of coarse breccia is cemented, or fused into one and the same mass with the underlying gneiss. In places they are both impregnated with a pale, green serpentine-like mineral, not unlike epidote, only that it is very soft.

Fig. 22. Sketch showing the alteration of the lowest quartzites, with the gneiss.
K. Bottom beds: M. Gniess, older metamorphics.

The accompanying figure is taken from part of the low scarp at this point and shows how the lowest of the quartzites has been altered to some extent with the gneiss. The underlying rock (G) is a distinctly foliated variety of quartzose gneiss, foliation north by west, south by east, with a dip of 60°—70° east; and it is overlaid by quartzite grits and sands (S. S.) which are dipping 5° east. The upper part of G is conglomeratic, but this is only the bottom or coarse gravelly layer with patches of sand and grit (S[1]). The most peculiar feature is, that the lowest beds of the quartzites are stringed, east-west, with white quartz; which strings also penetrate the upper surface of the underlying rock.

Signs of dislocation and folding.

Up to this point, the Goolcheroos have been lying on the gneiss in easy undulations pretty much like what would have been the case if the bed of the old Kuddapah sea had, towards its western shore, been not very roughly denuded ground with humpy hillocks, bosses or domes of granitic rocks, rendered, however, more rugged and ridgy in places by those very ridges, now much more sharply denuded than they were then, which are held up by the dykes of fault-rock. At and northwards of the Paipully country there are, however, indications of dislocation and contortion which show at intervals up to Kurnool.

East-south-east of Paipully, in the deep and narrow gorge west by south of Chellumpully, the quartzite beds are much contorted, and in one case there is a reversed dip. They thicken very much in this gorge, and there was evidently some faulting along north-north-west to south-south-east, and east-north-east, west-south-west lines, though apparently of not more than 50—60 feet. Along the north-north-west line a patch of the quartzites has been thrown down some 20—30 feet to the west, and there is a dyke of fault-rock running along this line. It does not appear, however, that this fault-rock had anything to do with the dislocation; or if it had, it must be much younger than the rock of the generality of the dykes in this district.

Down at the bottom of the gorge west of Chellumpully (or Chennumpully) where the dislocation and reversed dip of the bed is so evident, there are traces of granite banking up the nearly vertical beds of quartzite in the reversed dip. A section at the bottom in a north-north-west direction shows the following stratigraphy :—

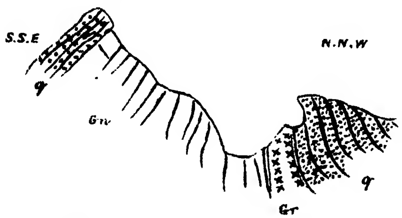


Fig. 23. Diagram section of the bottom of the gorge west of Chellumpully.
gn. gneiss : gr. granite : q. quartzite.

About six miles north of this the jasper pebbles of the conglomerates disappear almost entirely.

Altered junction again.

Again, north of the Coladunnakota tank the bottom beds of grit and conglomerate show signs of alteration. Here, the lowest bed is a dark bluish-grey vitreous quartzite grit with layers of white pebbles, and it is not separable from the grey granite beneath along the surface of deposition. Many of the great fragments of this bed are lying about with the granite still adhering, as though the blocks were made up of one uniform rock.

Conglomerate of adjacent granite.

The high hill to the north of Raiculcoontapilly is much traversed by granite veins, many of which contain a good deal of epidote; and the bottom beds of the quartzites contain pebbles and fragments of this epidotic granite.

Uniform run of outcrop broken by Gunnygull fault.

Such are the kinds and the principal features of the Goolcheroo beds up to Gunygull hill; and here their continuity is broken by a nearly east and west system of faults which has affected both these and the newer KARNÚLS: so that the strata of both formations have been dropped down to the north with a throw of between 3 and 400 feet, and thus it is that in great measure the Goolcheroo quartzites are still left much further to the west on the north side of the fault than they are on the south side.

Strata north of fault.

North of the faulted line the strata still present much the same features as are seen to occur southwards, though they are even coarser grits, and rather marked as a set of pebble beds. The pebbles are remarkable for their roundness; and even an uneducated eye would all along this scarp, and particularly near Kurnool, be struck with the evident aqueous formation of these beds. The slopes and ledges of the scarp are strewn with as recent-looking river gravel as possible, all derived from the weathering away of these bottom beds.

Most interesting and instructive examples of these pebble beds are to be seen in Jagernat Conda, just south of Kurnool; and again further south on the first ravine, where some temples have been built on and under the ledges of grits and gravel beds.

Felspathic grits.

The beds north of the fault are also remarkably felspathic in their constitution, the felspar being often of a red color and crystalline, giving the rock occasionally almost a granitic look. It is very possible that some of the felspathic grits occurring on the right bank of the Toongabudra below Kurnool, and referred to by Mr. Foote as of the *Banaganpilly* group among the KARNÚL ROCKS, may be really bottom beds of the KADAPAH SERIES.

Bottom beds thinning out at Kurnool.

At Kurnool, there is a very clear section exposed in the long canal cutting near Jorampoor, in which the bottom beds of the KADAPAHS are seen overlying a very irregular set of hornblendic and silicio-felspathic crystallines which are much traversed by trap. The bottom bed is very irregular in its thickness, seeming to have been thinly spread over the gneiss and occasionally thickening out slightly where it filled in the denuded hollows; and it is waving along gently, as a shore-bed might do on a roughish bottom. It is here a very coarse breccia and conglomerate of fragments of white and glassy quartz in a matrix of dark, brown, earthy silicious rock which was possibly derived from the wear of the silicio-felspathic bands occurring among the CRYSTALLINES to the south and south-east of Kurnool. This bottom bed is then covered by a thin set of quartzite grits and sands, which in their turn are overlaid by slaty shales. These make up a very thin set of beds: altogether hardly more than 40 feet thick at their greatest depth, east of Kurnool.

Vaimpully Slates and Limestones.

Die out east of Goolcheroo.

Throughout the length of outcrop just described, the Goolcheroo quartzites are overlaid apparently conformably by a series of shales or slaty shales and limestones which at Goolcheroo thin out and disappear, as already stated, between the bottom quartzites and others of the long eastern sloping hilly country between Goolcheroo and the higher ranges of the Pollconda hills south-south-east of Cuddapah.

Obscure faulting.

There are very good indications of a more or less northerly and southerly line of faulting in the hills on the east side of the inner valley east of Goolcheroo, but their absolute direction is not clear. For example, the east-west fault at the eastern end of the long valley, north of Goolcheroo, is continued into the northern base of the hill, east of the Cuddapah road, among quartzites: and, if one keep along in this direction, nothing else but quartzites and intercalated flags and shales are met with; yet in the little valley beyond this hill limestones and slaty shales are abruptly brought in on the western slope of the next hill, and show up that side of the turning up of the main valley. There is no trace of limestones between the east-west fault and Bankrapett; nothing but quartzites which seem to be as much a continuation of the beds south-south-west of that village, as of those which are different and higher in the succession of strata to the north-north-west of the same village. These clearly north and south faults, however they run, seem to have died away to the south, for Mr. Charles Oldham saw no traces of dislocation in the hills east and south-east of Goolcheroo. In this way faulting, as well as covering up by the overlying unconformable quartzites, may have had to do with the sudden disappearance of the Vaimpullys in this direction; though probably the last cause and thinning out have had the greatest influence.

Vaimpullys essentially a limestone sub-group.

In the belt of outcrop extending from the Cuddapah reach of the Paupugnee up to Kurnool, the series is essentially a calcareous one with frequent intercalations of silicious strata.

Intrusive trap.

In the Paupugnee valley the beds are largely associated, nearly in the stratification, with intrusive trap: and again, to some extent, in that part of the belt north of the Puspulla valley, and so on past Kurnool to the western edge of the Kistnah range of hills.

The limestones are principally very fine grained and compact in thick and thin beds, and are more or less silicious, and occasionally magnesian in their constitution. They are usually of pale grey colors; but pink, red, and greenish beds are not at all uncommon.

Character of limestones.

They are often frequently banded with white semi-opapue calcedonic chert, which when weathered presents a peculiar oolitoid structure. That is, these silicious bands are mainly made up of minute globular bodies consisting of concentric layers. No organic structure has been recognised in these little spheroids; nor is there any visible nucleus; they appear to be simply concretionary, and were possibly produced by the whirling of particles of sand or other hard material in the silicio-calcareous waters of the time. They are generally large enough to be clearly recognized by the eye, but the rock requires to be closely looked at. Unweathered pieces of the calcedonic chert, so common in the western slopes of the hills immediately west of Ryalcheroo, do not show the slightest trace of this peculiar structure. Not only does this structure show in the chert bands, but there are frequent layers of fine red quartzites which are full of the little spheroids. On weathered surfaces, they have frequently fallen out and left minute globular cavities in the rock.

Silicious bands of oolitoid structure.

From the Penn-air northwards, the limestones become more silicious and are gradually replaced to a great extent by the beds of the calcedonic chert and fine homogeneous quartzites, until north of the Puspulla valley there is hardly any limestone except near, or at, the top of the series.

Northwards, limestones become more silicious.

The lowest beds are generally red sands and shales, which are often ferruginous. Then there are calcareo-sandy beds: and above these the limestone beds, with their silicious bands and segregations, and intercalated purple earthy slaty shales, or clay slates.

The highest beds, as they are seen under the next overlying quartzites, are very various, owing principally to the fact that these quartzites are not always covering the same band in the outcrop. At one time they lie immediately on massive hard, compact, silicious limestone, while at another they lie on fine earthy shales which are sometimes of considerable thickness.

Different beds seen underlying the next group.

In the Paupugnee region, the quartzites are separated from the limestone series by a great intrusive flow of trap; while a good thick set of shales with calcareous bands comes between the trap and the more decided limestones. As the outcrop is followed out northward it is gradually found that the quartzites are overlying limestones, intruded on by trap, without any intermediate shales, as between the Chittravutty and Penn-air rivers. Further north, the quartzites of the Puspulla ridge are only separated from the decidedly silicious limestone of the Mulkapoor terrace by a thick flow of trap.

Towards Kurnool the series has thinned out a good deal, and the beds are lying at a very low angle. Opposite Kurnool there is only a trace of shales at the base, when the limestones come in; these are highly altered by the great trap flow or flows, while the higher beds are mostly silicious and oolitoid. At the passage of the Kistnah into the Nullamullays, there are perhaps 100 feet left of these beds, and there they are calcareous and slaty shales with thin beds of serpentinous limestone and bands of intrusive trap.

Strata thin out as Kurnool is approached.

Again, in the Paupugnee valley the series is nearly all of silicious limestone beds, which, however, appear to thin off very rapidly to the eastward into red sands and shales. The thinning out is, however, probably very deceptive, for the limestones which are so strong along the Paupugnee may of course be largely concealed first by superincumbent quartzites, which bend sharply round and cross the river at Boodyapully; and then by the newer KARNÚLS which are here spread out over the Cuddapah basin.

Thinning out at south end.

The action of the intrusive flows of trap upon the beds of this series is very well shown both above and below the greenstone sheets; but it is strange how they have run so evenly with the stratification. In no section have we seen any case of trap cutting clear up across the beds: and yet as the maps were worked out, it became evident that the flows must have crossed, though at a very low angle, from one set of beds to another; or, as is more probable, that the edges of different sheets have come in contact with each other at certain points as they were poured in between the beds.

Intrusive character of trap.

There may of course be many cases of cutting up across the beds hidden by debris; but it is curious that we have seen none in this belt, which was very carefully examined. Indeed, it seems very evident that these intrusive traps were poured in between beds of both these limestones and of the upper quartzites at one and the same period. At the southern end, in the neighbourhood of Bonalla and Wobiapully, some ten miles south of the Chittravutty, all the trappean outcrops of the Paupugnee are dying out northwards, and appear to some extent to cut up at very acute angles into the strata of the superincumbent group; while in the Puspulla ridge, on the north side of the east-west valley of that name leading to Banaganpilly, there is an analogous case.

No cases of direct cutting across the beds.

In the first region, the country is largely obscured by debris, and the absolute continuity of the Paupugnee traps into those of Bonalla, if it exist, is not seen. On the other hand, the great flows in the Puspulla ridge are comparatively clear; at least it is certain that they occur between strata of the ridge quartzites, between the quartzites and the limestone of the subjacent series, and between the limestones themselves: and these apparently different flows are all traceable into a broad outcrop of greenstone bands, which are partially obscured by recent travertin deposits.*

Further west-south-west of this point, opposite Jelldoorga, there is another very complicated arrangement of quartzites, slates, limestones,

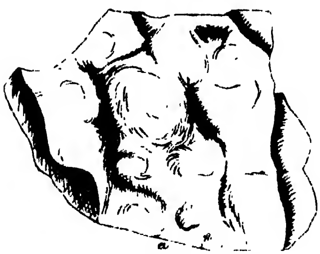
* The outcrop of greenstone in the quartzites comes in contact with the outcrop of trap between the quartzites and the subjacent limestones: and there is no trace of any intermediate band of quartzites between trap flows on the western side of the ravine.—W. K.

and traps, in which apparently the same outcrop of trap runs in between all these strata; but there is a good deal of contortion and some faulting (connected with the evident lines of dislocation to the east) which makes the succession of the beds very doubtful. On the whole, however, the trap certainly appears at this point to be intrusive.

The sudden dying out of these trap sheets, both in this last locality and in the limestone terrace below and north of Puspulla Gonda or Conda in the Camlapoor valley, is hardly consistent with the generally easy and uniform succession of the rest of the strata.

Alterations of limestone, &c., in contact with trap.

In the Paupugnee valley, the limestones and slates or slaty shales in immediate contact with the traps are altered in a marked manner. They are stringed with white and pink seams, patches, and knots of a rock of serpentinous or magnesian constitution easily weathered into a white powder. Occasionally these seams are of pale green color, and are then a calcareous serpentine. The lamination of the beds in contact is undulatory and wavy: and the more massive and silicious limestones, not in such close contact with the traps, are much segregated in what appear on the edges of the beds to be corrugations. On the surfaces of the beds, however, it is seen that these corrugations are merely sections of rude columnar segregations.



a

b

Figs 24, a, b. Surface and section of a block of corrugated or segregated limestone: the walls and concentric laminæ are of silica.

Further north again, beyond the Penn-air, some of the beds in the upper part of the series are seamed with serpentine, and there are strong traces of trap close by, which, as far as could be made out in a part of the country so obscured by cotton-soil, appears to underlie these evidently altered beds of limestone. The locality is about six miles south of Ryalcheroo,* in a low hill to the east-south-east of Vengunnapully.

Limestones with serpentine.

The strata crop out round the western side of this hill and show one or two thick beds of pale green and white limestone, thinly interlaminated with pale green or whitish semi-translucent serpentine. There are besides thicker seams and rocks of the mineral; but specimens obtained from these are very brittle, and break into irregular semi-conchoidal and cuboidal little masses which are two small to be of any use except for very small ornaments. Possibly, however, deeper quarrying might produce less friable specimens.† The following is a sketch of the edge of one of the beds, showing how the serpentine occurs in the limestone:—

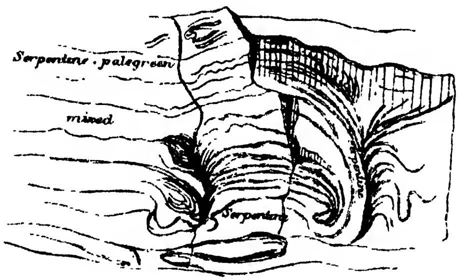


Fig. 25. *Ryalcheroo Serpentine.*—Part of the outcrop of one of the serpentinous beds, showing how the mineral is segregated. The broader and lighter bands (s) are those which are most serpentinous in their composition, and these are laminated with thin and rapidly undulating layers of calcareous matter, while the darker and more numerously laminated bands are the more calcareous ones.

* In the western edge of the Bellary District, on the high road, or north-west line of railway, between Cuddapah and Gooty.

† At present the workmen at Ryalcheroo only carve ornaments out of small blocks of the pale green (waved with white and dark grey stripes) serpentinous beds of limestone.

There are, again, further traces of serpentinous limestone in Mulkapoor terrace, north of the Puspulla valley, where the strata are between sheets of trap: and those beds which are in close contact with trap, either above or below, are impregnated with serpentine in strings and segregations.

Steatite or 'Bulpum.'

Further north still, between Moodwaram and Yenkatgerry, the shales of this series are very magnesian, some of the layers being nothing else but fine grey and greenish steatite. There are also seams of the finer form, or 'French Chalk, which is here called, and known over South India, as 'Bulpum.'* This is the quarrying place for steatite in the district.

Serpentinous limestone near Kurnool.

The next marked locality of serpentinous limestone is close to Kurnool on the east side of the suburb of Torapore. Here, easy rolling beds of pale green and white laminarly-waved limestone occur underneath the great spread of trap further eastward; and similarly altered beds show again nearer to Kadrabad, lying on the same sheet of greenstone. Generally, these beds are very pale green or yellowish; but there are occasional cases of darker green strata, with laminæ arranged in frequent convolutions, which would give a finely clouded marble.

Vaimpullys overlap the Goolcheroos on the Kistnah.

The same limestones and associated silicious beds, with what appears to be an extension of the same trap flow, show at intervals along the banks of the Toongabudra, below Kurnool, up to the entrance of the Kistnah into the Nullamullays. Inside the Kistnah gorge there are frequent traces of serpentinous bands and steatitic layers, associated with trap: and here the series is lying directly on the gneiss without any intervening sands or gravels of the next lower division of the sub-group.

* This 'Bulpum' is largely used by the people as a chalk for writing on their blackened boards, or small folding books of blackened paper, or canvas. The associated bands of steatite and steatitic shale, which are of various shades of brown, green, and purple, are carved at Kurnool into paper weights, &c.; some of which are very well cut, and extremely quaint in their designs. The semi-translucent character of the yellow and green colored rock makes it admirably suited for quaint carvings of groups of crabs, scorpions, or frogs, which are the favorite subjects of the artists.

Denudation of Vaimpullys.

Over the whole of the belt of these limestones and slates south of the Ryalcheroo and Gooty road, the strata are denuded into a set of parallel valleys between low rounded hills, which hills are quite characteristic in the marked way in which they are contoured by lines of outcropping strata showing along and round their flanks. The beds are dipping at so low an angle—as a general rule, from 5° to 10°—that they often crop out all round a hill or series of hills, giving the country a most picturesque look, with its ringed and sinuously parallel-lined ridges. This peculiar feature is seen at intervals very well displayed, more particularly in the Parnapully area, and again to the north of the Penn-air.

Fig. 26. View from Biddanumcherla, looking south-westward, showing the contoured character of the limestone hills.

K4. Puspulla Quartzites (Naggery Quartzites).
K3. Vaimpully Limestones, } *Paupugnee Beds.*
K2. Goolcheroo Quartzites, }

There is no such characteristic form of denudation among any of the limestone series in any other part of the area.

Thickness of group.

The greatest thickness of the Vaimpullys is over 3,000 feet, while that of the Goolcheroos is over 900 feet; but they are never seen both together equal to the sum of these estimates.

Chapter 3.—The Chey-air beds.

Poolavaindla, or Naggery Quartzites.

Paupugnees overlaid unconformably by a second series.

Returning again to the examination of the western belt of quartzites and slates, it is found that the *Paupugnee Beds* are overlaid unconformably by another series, of which the lowest beds are quartzite sands, grits, and conglomerates. These overlap the Vaimpullys to the north on the Kistnah river; as they likewise do to the south, over the rather obscure hilly country in the neighbourhood of Cuddapah.

Poolavaindla quartzites.

For so much of the outcrop as is thus certainly known, it is perhaps better to treat of the beds locally under the name of the Poolavaindla* quartzites, though these rocks do not show in any force there. They might be named after some prominent peak in the long and narrow belt of ridges which they form by their hade up to the westward; but there is no one of these sufficiently distinctive.

To the north, in detached areas.

Commencing from the north, these rocks are seen in detached areas until the broad shoulder of country opposite the Oopalpád plateau is reached. First, in the western part of the Kistnah Nullamullays near Margooty; again, in the low Gardimuddoo range of hills east of Kurnool; and then, over part of the elevated country between the Gunnygull hill fault and the Puspulla valley.

Continuous thence to Cuddapah by Puspulla ridge.

Opposite or west of the Oopalpád plateau, the inner or Puspulla ridge of quartzites is of this sub-group, and as a more or less elevated run of this kind it is thence continuous right away down until immediately south of Cuddapah; whence it is traceable, though with some obscurity, into the western hills of the Chey-air valley as the Naggery quartzites. The continuity of this western outcrop is concealed at various points between the Kistnah

* Poolavaindla, a large and well known taluq village, some 40 miles west by south of Cuddapah.

and Cuddapah by newer KARNÚL rocks; but there is no doubt that the several patches of outcrop show the same series of quartzites.

South of Cuddapah continuity broken.

Immediately south of Cuddapah the outcrop is not only concealed, but is at the same time broken by an obscure system of faults.

Constitution of sub-group.

The strata of the Poolavaindlas are quartzite sandstones, grits, flags and conglomeratic or pebbly beds; and, where the unconformity between these and the next lower group is well seen, the lowest beds are full of angular and round fragments of some of the subjacent strata.

Intrusive trap.

To a certain extent, and more particularly in that part of the outcrop along the north side of the long Puspulla valley west of Banaganpilly, these quartzites are traversed by intrusive trap, which, in its flows, has deviated only very slightly from the lie of the strata. There are further traces of this intrusive trap at Ulloor on the great canal of the Madras Irrigation Company, some ten miles east-north-east of Kurnool: and the rock is again seen in the Margooty hills on the Kistnah river. Towards Cuddapah, or to the south of the Chittravutty river, the strata are again very closely and extensively associated with great intrusive sheets of greenstone: indeed, the lowest beds are there lying directly on trap of considerable thickness, and apparently quite conformable with it.

Unconformity to subjacent series not always clear.

A peculiar feature of the superposition of these quartzites upon the subjacent strata is that, for miles and miles of their outcrop, they are apparently quite conformable, when quite suddenly at certain points they are found to be lying on the acutely bevelled edges of the lower beds and to be full of pebbles and fragments of these. From the Paupugnee, nearly up to the Puspulla valley, there are no very clear signs of unconformity, except in the cappings which are left on some of the limestone hills to the west of the main quartzite ridge, and here

the dip of either the one or the other set of beds is so low and the sections so obscured by debris that nothing certain could be made out. However, the fact of the contained pebbles at various points being clearly of the underlying rocks, and the strong unconformity displayed to the south-west of Cuddapah, were decisive as to this distinct form of demarcation between these strata and the *Paupugnee beds.*

On the Kistnah.

The Margooty hills, on the Kistnah, are made up of quartzite sands, flags, and pebble beds, which underlie the slaty shales of the little Doorgum valley; but the order of succession is much obscured along the south-western slope.

Contain fragments of Vaimpullys.

On this account the breccia beds are not at all clear in their relations to the other beds, appearing sometimes to be the uppermost and at other times the lowest of the series. The fragments in the breccia are of various pale-colored jaspers and cherts, with others of a peculiar white or buff silicious chert, which is made up of countless minute spheroids, giving quite an oolitic structure to weathered fragments. These contained fragments of oolitoid silicious chert are common to the lowest breccias and conglomerates of nearly the whole extent of the western outcrop of the Poolavaindla (Naggery) quartzites. They are evidently derived from beds of such rock in the subjacent group.

Spread out over gneiss.

At the passage of the Kistnah, at Someesalla and Shideshver, a ridge of quartzites has been cut through, which ridge eventually turns out, in its extension to the westward, to be formed of gneiss capped by quartzite conglomerates and breccias containing these fragments of oolitoid rock. And thence the same beds are spread out further west in the low ground and as cappings to some outlying hills.

Mr. Foote considers some of these beds to be KARNÚLS.

When describing the KARNÚL rocks, it was stated that Mr. Foote is inclined to look on these outer quartzites as belonging to the *Banaganpillys,* or diamond-bearing beds of the district; and that he had found some fragments of this oolitoid chert in the conglomerates of Singuwarrum hill. The

preferable conclusion seems, however, to be that these pebble beds and breccias to which he refers belong to the Poolavaindlas (Naggerys), and that they have here thinned out over the subjacent group in the series until they lie directly on the gneiss. At any rate, a difference cannot be recognized between the quartzites of the long E. W. ridge and those of the other ridges closing up to it from the Kistnah hills. At the Someesalla pass of the river, the quartzites of the ridge are there overlying a calcareous set of shales with bands of serpentinous limestone and associated trap. These are clearly belonging to the next lower group; and they in their turn rest immediately on the gneiss, having thinned out over their lower member which is very persistent in other parts of the field.

Mr. Charles Oldham refers frequently in his notes to the peculiar brecciated constitution of these quartzites, and to the fact of their containing fragments of white amorphous silicious rock, in which, however, he had not at the time noted the oolitoid structure. It is to be remembered that this peculiar structure is not very readily seen in these contained fragments except on weathered surfaces. Mr. Foote was the first to note this feature: and then I found afterwards that the silicious bands in the limestones of the Vaimpullys are mainly so constituted.

In the Gardymuddoo hills, east of Kurnool, the quartzites are full of fragments of these same chert bands, the slopes of the hills being covered with the very hard angular debris of the same rock. There is a like quartzite sandstone breccia in the patch between the Puspulla valley and the Gunnygull line of fault: and here the beds are directly overlaid by a great sheet of intrusive, and in places, amygdaloidal trap. Thence southwards the breccia and conglomerate beds are not so clearly made up of these oolitoid fragments. But they again come in rather markedly in the low southerly sloping hills west-south-west of Cuddapah.

Character of strata in the ridge of continuous outcrop.

Along this ridge of continuous outcrop the strata are generally thick-bedded sandstones and grits, with occasional bands of conglomerates and pebble beds full of reddish jaspers and chert pebbles. They are obliquely laminated and often ripple-

marked. Where the outcrop strikes across the Chittravutty river reddish grey grits and sands in massive beds overlie the beds of conglomerate and pudding-stone which are full of fragments of carnelian and jasper. The rock is so crowded with these that it seems locally blotted over with blood-red spots; though it is generally full of grey, buff, brown, and blood-red bits of quartzite, carnelian, striped red and black jasper. The detached hills on this side of the river are capped with the remains of thick beds of an extremely coarse white and grey mottled reddish conglomerate. This is very much the usual constitution of the series all along this outcrop. The average thickness of this part of the series is about 500 feet.

Unconformity on the Paupugnee.

The unconformity of the quartzites on the series of limestones beneath them is perhaps most clearly shown in the sharp twist round from the long north-east scarp on the left bank of the Paupugnee, across the river southwards into the country on the right bank. The dip of both series of rocks, for instance in the low hills south of Boodyapully, is so low and varies so little that the unconformity is not seen except in long sections, as for instance along the southern face of the east and west spur of hills between Pugdallpully and Chinnulpenta. This low range of hills is capped by breccias and pebble beds of quartzites, which are on the north side overlying beds of the limestone series different from those which they overlie on the south side of the ridge. Here the bottom breccia beds are very ferruginous* and full of fragments of oolitoid chert. At the Paupugnee side of the hills the limestone outcrops are covered by grey brownish and reddish grits in thick beds, which strike into the river and appear on the other side as the beds which eventually turn round and form the scarped Annamalla ridge.

* Mr. Charles Æ. Oldham notes this constitution as follows:—"South-east of Boodyapully the hill is of hard, grey quartzite, and in passing up the slope several bands of rich iron ore (hæmatite) are crossed, much of which is extremely rich, having quite a metallic lustre. It has been picked and worked, but fuel must be very scarce, the hills about being singularly devoid of jungle. The ore is very abundant, covering at least a square mile and coming well to the surface."

A north and south section through Chinunulpenta shows as in the accompanying sketch.

Fig. 27. Diagrammatic section across the Boodyapully hills, showing unconformity of Poolavaindla quartzites.

Series of faults in Paupugnee valley.

In this part of the field, or along the Paupugnee valley, these quartzites have, with the strata both above and below them, been subjected to frequent though not very extensive dislocation, by which several sections of the country have been, by a succession of step-faults, thrown down to the southwards. These dislocations are tolerably evident in the line of scarps overlooking the Paupugnee river, and more particularly at the Annamalla pass, where the Mogamoor river cuts across the ridge; at the gap further south opposite Cotapully; and again, in the shallower gap north-west of Vaimpully. There are other fainter traces of faulting between these points. Unfortunately these several lines were not clearly traceable into the great series of slaty shales and trappean rocks above the quartzites, mainly by reason of the covered-up condition of the low country to the

west of the quartzite ridges, and the consequent impossibility of tracing out the different outcrops of slates, limestones or traps continuously for any long distance. The direction of these stepped faults appears to have been generally north-west to south-east, with a downthrow to the south of about 470 feet vertically in the southernmost break. This throw decreases in the succeeding northerly steps.

Partly accounts for abrupt bend in strike west of Cuddapah.

To some extent, this series of parallel dislocations accounts for the apparently abrupt bend up and narrowing of the outcrops of the strata west of the Annamulla ridges, though the general basin-shaped bend must have been mainly given long prior to the period of dislocation now referred to. Indeed, the original floor of the formation very probably had something of this form; which was subsequently much exaggerated by the squeezing up which the whole KADAPAH formation received from the eastward.

Outcrop at Goolcheroo.

The Goolcheroo end of the outcrop bends round in the low hills south-west of Chintakonadinna, covering up unconformably the red sandy, slaty shales with limestones of the Vaimpullys. The lower beds are very coarse thinnish-bedded brown grits and pebble beds, which again overlie an exceedingly coarse conglomerate of fragments of quartzite of many colors, brown slate, and some jaspers. Occasionally it is a very ferruginous conglomerate. The whole slope of this higher part of the hill consists of three beds which again overlie grits. The two form the scarp of a steep western slope leading down to the valley below, and in this on the opposite side are unmistakeable limestone beds of the Vaimpullys forming a round little hill with contoured outcrops exactly like other hills in the northern part of the Vaimpully belt. But between the quartzites of the top of the hill and the limestones, there are some red and white streaked coarse calcedonic and jaspery beds, with quartz and calc-spar strings, which are rather broken up and knocked about, and, as it was eventually

seen, are in the long fault lines west of this. These beds, which are lying easily close by, are laminated with the white oolitoid chert of the Vaimpullys.*

Obscurity in southerly continuation of beds.

Now, the conglomerates, &c., just described, are evidently the same beds which strike round here from the ridges on the western bank of the Paupugnee, but their continuity with the quartzites on the eastern side of the Bankrapett stream is hidden by alluvium and possibly broken by some faulting. In the hill plateau south-east of Bankrapett there is, however, the same series of quartzites again overlying red shales and limestones which eventually thin out and disappear.

Fig. 28. Section across the valley south of Cuddapah, a mile south of Polleonda—

Horizontal Scale 2 miles to one inch.

B. Q.	Byreneonda Quartzites ...	... *Nullamullay Beds.*
P. S.	Poolumpett Slates ...	... *Chey-air Beds.*
P. Q.	Poolavaindla Quartzites	
V. L.	Vaimpully Limestones ...	.. *Paupugnee Beds.*

Section south of Cuddapah.

Taking a section across the valley south of Cuddapah, the conglomerate and grits of Chintakonadinna hill are overlaid by thin sands and sandy shales and more quartzite, which are the rocks close up to the Bankrapett stream. Then there is nothing seen but alluvial deposits until the Boogoo stream is

* The oddly picturesque masses of quartzite strata capping the plateau hills beyond (south of) Cummawarpully are, I think, of the newer KARNÚLS; they overlie, at any rate, the quartzites referred to above, further westward.—W. K.

reached, and here are quartzite, grits and sands again in well-exposed beds, which further to the north are arranged in an anticlinal. Over these are more sandy shales and then a fair thickness of white quartzites in a synclinal fold on which the Pollconda Pagoda is built. Over these come more sandy shales and red slates, which a short distance south begin to show traces of limestone beds, and, finally, these are overlaid (?) unconformably by the quartzites of Pollconda.

Quartzites beneath Pollconda Pagoda apparently Poolavaindlas.

The question is, do these quartzites with intercalated slates or sandy shales of the valley and the Pagoda all answer to the Poolavaindlas (Naggerys)? if they do, they have thickened out considerably from what the sub-group is in the Annamalla ridges on the west bank of the Paupugnee; and an intermediate band of sandy slates has come in which does not show in that ridge. There are also no traces of traps which are so prominent a feature on the Paupugnee. This last feature is of course accountable for by the possibility of the volcanic action not having extended in this direction.

Pollconda Pagoda quartzites are Naggery beds.

The final settlement of this question must only be left for closer examination than we have been able to bestow on this part of the field. Certainly there is a series of rocks, of which the Chintakonadinna beds are the lowest, extending southwards into the Chey-air country, and they to all appearance have overlapped the whole of the *Paupugnee* beds. But as these are traced out, it is found that the quartzites of the Pollconda Pagoda are those which are mainly exposed; the shales beneath and the quartzites of the Boogoo stream in the section appearing in the western scarps. The group thus found to form the western side of the southern part of the field has then become the bottom series in this region, and constitutes what we have called the 'Naggery Quartzite,' from the well known and conspicuous Naggery Nose hill west-north-west of Madras.

The Naggery quartzites occur as the capping and summit peak of this hill. Thence northwards they are seen in the Narnaveram and Calastry outlying ranges of hills, and beyond this again they form the hills of Tripetty, and so extend right up to near Cuddapah as the western edge of the country under description.

Southern outliers of KADAPAHS.

Eeshwarnacoopum mountain.

In the Nullamullays they seem to be represented by the rocks of the main mass of the Eeshwarnacoopum.

Eastern outliers.

The Yellaconda or eastern ghâts are fringed at rare intervals by a few outlying hill ridges, three of which are capped by quartzites, which may possibly be representatives of these Naggery beds, though it is quite impossible to recognise any particular resemblance between the one and the other more than between these and any other group of quartzites and slates in the KADAPAH formation.*

Naggery quartzites thickest at southern end.

This sub-group is thickest at the southern end: giving grand scarped cliffs in the outlying Narnaveram hills, &c., and those of Tripetty, of about 900 feet in height. The greatest thickness down here must be from 1,000 to 1,500 feet. If the Eeshwarnacoopum beds be really representatives of the Naggerys, the greatest thickness is far beyond this.

From Naggery to Cuddapah, there is a gradual decrease in thickness, until underneath the slates with limestone of Pollconda, there are only some 600 to 800 feet.

Character and details of Naggery beds.

The series throughout is made up of altered sands, grits, and conglomerates, in thick and thin beds, with flags and occasional thin bands of slates or slaty shales. With such a long outcrop of these strata as there is along the

* Mr. Foote considers the Byrawadi beds as belonging to the Byreneondas.

western edge of the field, there must necessarily be much change in the constitution of the rocks, so that any general description would be hardly illustrative of the series as it may come under the notice of future observers: so that, perhaps, it is better to give short details of observations which were made either by Mr. Oldham or myself at different portions of the outcrop which are more particularly worthy of notice.

Triple banded.

In the outliers at the southern end of the field, there is a triple series of sands, grits, and conglomerates, which, in the easternmost range of hills near Madras, the highest point of which is Cambauk Droog, attain a thickness of about 1,500 feet. Here the quartzites rest quite naturally on the crystalline gneiss which forms the greater part of the basement of the range; though they roll about to some extent, and are eventually much crushed and lie abruptly on and against the gneiss in the Calastry ridges, further north and west.

At the bottom of these cappings there is generally a series of thick and massive beds of quartzite-sandstones and conglomerates, which are more cleaved and jointed than the higher strata. These massive beds are from 400 to 500 feet thick; above which come about 700 feet of thinner bedded sands and flags; above these again there is a series of massive and thick bedded quartzites (often very coarse sandstones and conglomerates) which are more ripple marked and not so coarsely conglomeratic as the lower band. In the middle band there are occasional beds of talcose flags (schistose) which are occasionally strongly seamed with white quartz. This is the section seen in Ramagherry,* and it is very much the same in the neighbouring outliers, with, however, a varying thickness and presence of the three bands of strata. The peak of Naggery Nose, for instance, is only made up of a remnant of the lowest

* Southern end of the Cambauk range, about 1,500 feet above the sea, a picturesque little plateau with tremendous cliffy precipices all round; summit only gainable by broken flights of steps, which have been built here and there up a rift in the cliffs.

beds, while the long easterly part of this ridge shows the threefold system of bands at its eastern extremity.

Conglomerates.

The pebbles* and shingle of the conglomerates in these outliers are always either of quartz, or quartzite, with occasional fragments of red-banded jasper. The fragments of quartzite are sometimes conglomerates themselves.

Strata west of Chey-air field.

The broad belt of Naggery quartzites edging the Chey-air valley on the western side consists of the same kinds of sands, grits, and conglomerates, with bands of flags and occasional strips of intercalated slates. Mr. Charles Oldham, who alone examined this part of the country, refers to them as follows:—He notices the threefold division of the beds in the Naggery and Narnaveram hills, &c., and states that a similar sub-division appears to exist to some extent along the western side of the field, "a band (more or less well defined) of thinly laminated and rather flaggy beds, occasionally somewhat slaty in character, separates two bands of hard massive quartzites, of which the lower is more frequently pebbly and conglomeratic, and the upper somewhat finer and frequently well rippled."

Tripetty scarps.

The intermediate band of slates is very well defined along the southern flanks of the Tripetty hills, where a second scarp of quartzites is seen well behind and above the lower scarp of fine precipitous cliffs.

Mr. C. Æ. Oldham's notes.

Taking Mr. Oldham's notes from the point where he shows that the calcareous slaty and shaly beds of the Vaimpully sub-group have disappeared under the quartzite hills east of Goolcheroo, we find the following:—

Character of sub-group.

"Along the range of hills east and south-east of Veerapully, the lowest bed is a hard purplish and grey quartzite, rather coarse and false bedded. Over this are more flaggy and slaty beds and some indurated shales. On these sometimes rests a little very ferruginous coarse and hard

* I have never seen a fair pebble or shingle boulder of gneiss or granite, except in the locality mentioned at p. 158, in these or any other quartzites of KADAPAHS or KARNÚLS.—W. K.

quartzite frequently well rippled. The hills here are lower than those further north, and the hard grey quartzite* which is seen capping the other hills is apparently wanting.

"East of Sonepoy, over the denuded surface of the granitoid gneiss, hard purplish and grey quartzites form the upper part of the hill stretching across the sloping table-land eastwards; succeeded by thinly bedded silicious flags or finely laminated indurated clays and shales, green purple and brown.† These beds again are covered by hard grey and whitish quartzites.

"In this neighbourhood the lowest bed next to the gneiss is sometimes, but by no means always, conglomeratic. For example, south-east of Veerapully, the lowest bed where it rests on the denuded surface of the granitoid gneiss is a hard greyish quartzite, almost entirely devoid of granular structure in appearance. Over this is a coarsely pebbly or conglomeratic sandstone, with pebbles of quartz and quartzite; over this more flaggy and some hardened shale beds. A similar succession of strata prevails along the range here; but to the southern end of it, the harder and more massive beds appear to thin out, and the flaggy and slaty beds come nearer to the junction with the metamorphic rocks. Some of the lower beds here are well rippled, and there are apparent marks of surface cracks.

"Further south, near Raiawaram, the lowest bed is a rather coarse hard greyish quartzite of no very great thickness, perhaps 200 feet. This is in parts pebbly, but not conglomeratic. Above this there are 200 to 250 feet of hard slates, greenish and pink; and above these, forming the upper part of the hill and extending eastward over the sloping table-land, a grey and brown weathered ferruginous quartzite, with occasionally a lateritiform surface coating. The dip throughout is at very low angles, 2° to 5°, (occasionally as much as 10°), to east-north-east. Ripple marks abundant in the upper beds.

"Again east by north of Goondaulbyle, the lowest bed seen is a massive clunchy hard, but somewhat earthy quartzite (or perhaps sometimes it may be better described as a very indurated silicious clay-stone), lamination very indistinct, but the general bedding in the mass recognizable. Above this, flaggy quartzites and slaty beds of no great thickness, perhaps 100 feet. Above all, a hard ferruginous quartzite in thick beds, locally in bands very rich in iron (in fact an arenaceous clayey ironstone.)‡

"East by north of Chintacoonta, still further to the south, there are very similar beds. The lowest a massive somewhat earthy quartzite in beds of 20 feet or more without visible parting or lamination,—of these about 200 feet.

* This hard grey quartzite is to all appearance the same as the quartzite on which the Pollconda Pagoda is built.—W. K.

† The shaly and flaggy beds below the Pollconda Pagoda quartzites are like these.—W. K.

‡ Collected above the Cudparaty pass and carried down by coolies and bullocks to be smelted below at Chintacoonta and other villages. On some of the still higher grounds there appears over this series a hard grey quartzite, and locally a little laterite, probably the result of decomposition *in situ* of some of these ferruginous bands.

"The same very ferruginous band or bands continue, and the broken pieces which lie about abundantly are carried down for smelting at Nerrabyle (Nerrabylegudda of map).

"Further east, towards Jonelroshy Coopa, the quartzites come lower down and form fully half the height of the hill, and here there appears a greater thickness of what is usually the upper bed, a hard grey coarse quartzite, of which there is here and round by Tellaralpate* and eastwards to Toombarkona, &c., a very considerable thickness rising to a greater elevation than in any other part of the district. From this south-south-east and eastwards, north of Tripetty, the hills rapidly diminish in height towards Kirkumbady (Curcumbode) where the quartzites are found forming the base of the hills."

Boundary between Naggerys and CRYSTALLINES a natural one until near Kirkumbady.

Thus far the edge of the field is a natural boundary, the scarp of the lowest beds lying along up the slope of the hills, and so it continues until near Kirkumbady, where the Naggerys and the gneiss are brought into juxtaposition. Some distance further east, the next sub-group of slates which are overlying these quartzites in the low valleys, by which the railway from Madras to Cuddapah enters the field, are also brought into juxtaposition with the gneiss; and finally in the southern extremity of the Yellaconda or eastern ghâts, there is a roll up of the strata by which the bottom quartzites are partly brought up to the surface, and ultimately, with their overlying slates, roll down sharp to the east and lie in contact with the gneiss on the Nellore side of the country.

Kirkumbady fault; downthrow of 1,000 feet.

There is thus a more or less east and west line of fault along the southern extremity of the field by which the KADAPAHS have been thrown down to the north to the extent of fully 1,000 feet at the eastern end of the line.

Tádapurtee (Poolumpett) slates, with limestones.

Poolavaindla quartzite overlaid by a slate series.

On again taking up the most perfect section of the rocks, on the western side, from the base of crystallines upwards, it turns out that the typical Poolavaindla (Naggery) quartzites are overlaid by a great series of slaty shales with

* Tellaralpate is given in the Trigonometrical Survey Records at 3,824 feet above sea level. For access to these Records I am indebted to the kindness of Colonel Priestley, Superintendent, Revenue Survey, Madras Presidency.—C. Æ. O.

limestones and volcanic ejections. These are most largely displayed in the broad valley crossed by the Penn-air, west-north-west of Cuddapah, of which Taudapurtee* is the principal town. The rocks are continuous in their outcrop for a long distance, until towards Kurnool they become covered up by the newer formation, though they are again traceable in the Kistnah, where they eventually die out and are overlapped by superincumbent beds of a higher group. Towards Cuddapah they are again completely covered up by the KARNÚLS of the Cuddapah basin; but apparently come again to light in the slate band with limestone under the quartzite of Pollconda hill. The lowest beds, or a thin set of pale-colored fine shales, rest quite easily and naturally on the Poolavaindla beds; and there does not appear to be any unconformity between them and the quartzites on which they lie.

Character of Tâdapurtee slates.

The series is mainly made up of fine slaty shales, with bands of flags and thin beds of fine quartzite sandstone, in which are a good number of intrusive and of contemporaneous runs of greenstone, with which are associated other volcanic deposits. Near the base of the fine shales is a band of subcrystalline limestone beds, with which are intercalated thin layers of felstone or petrosilex, over which come two thick flows of greenstone. Between this trap and another thick flow, some 400 or 500 feet higher up in the series, comes a peculiar set of well marked ferruginous chert and jasper beds with sandstones and shales. These with the great flow of trap are again succeeded by an immense thickness of thin-bedded shales, sands, flaky granulated shales (which are probably 'ashes'), silicio-felspathic layers, and a few flows of hornblendic rocks which fill up the wider open belt of this valley between the western ridges and the more inland run of hills of Beddadoor, Condapooram, &c. At the base of this inner line of hills is a second series of limestone beds with silicio-felspathic bands, ashes, felspathic sandstones, and two and some-

* A taluq village of the Bellary District.

times three distinct flows of trap, which are again succeeded by the different shales, &c., until near the Gundycotta range, when red and purple shales come in with bands of thick-bedded quartzites. These are the highest beds, and are overlaid by the quartzites of Gundycotta, which constitute a new group.

Three classes of rocks in the series.

There are in this succession three classes of rocks to be more particularly noticed; the traps and silicio-felspathic beds, the jasper series, the limestones, and the shales, which are the dominant deposits.

Slaty shales.

The term shales is hardly a correct one, for they are cleaved, sometimes rather strongly, though they are never so close in their character to true slates as those of the Nullamullay and Cumbum country yet to be described. It is very difficult at times to distinguish the results of cleavage from those of jointing, especially of the north-south system.* Besides, the shales may after all be thus jointed to a maximum extent in this direction which is very nearly, if not exactly, with the cleavage. Both cleavage and jointing have, however, been impressed on these rocks; the latter very strongly. It thus happens that these planes, combined with the original tendency to separation along laminar surfaces, have produced the peculiar spicular form of the disintegrated fragments so peculiar to some of the finer shales. The western slopes of the Gundycotta range are often covered with a debris of small rudely needle-shaped or spicular fragments of shales.†

Cleavage generally faint.

The force of cleavage was so faint as never to have overcome or obscured the laminar tendency to separation. This last feature is always to be recognized, and is always capable of being taken advantage of in the quarrying of the

* The direction of the joints may vary 10° on either side of this general run.

† It will be seen further on, that some of the shales in the southern representatives of this sub-group weather in the same manner.

rocks. The other and easier surfaces of weakness are of course those of jointing, which is very often strong in three main directions, *viz.* : east-west, north-south, and diagonally. The finer shales—often on the exposed slopes in wet weather almost like hardened mud—are very friable and break up in the spicular form already described. This last variety is mostly in the upper part of the series. The strongest development of cleavage, and this is not much, occurs in the north-eastern part of this belt of outcrop under and alongside the Paneum hills, and more particularly in the fine valley of denudation on the north-west flank of the Oondootla plateau.

Peculiar variety of shales similar to others in Gwalior rocks of Central India.

The slaty shales just described form by far the greater portion of the whole series subjacent to the quartzites of Gundy-cotta; but there are other shales intercalated with these which are very peculiar and interesting, for they have no representatives anywhere else in the KADAPAH formation except at the western side of the Kistnah Nullamullay range. They are, at the same time, remarkably like some shales, also associated with traps, which occur in one of the groups of a series of rocks in Central India provisionally called 'Gwaliors'* which are of much older age than the VINDHYANS.

They are, when weathered,† softish, well-laminated, fine-grained and compact, or coarse and flaky, shales of all sorts of brown, purple, red, and grey colors, and either speckled, or full (in the planes of lamination) of minute rudely-shaped spheroids or ellipsoids of often the same composition as the rock itself, and varying from the minutest size up to that of a small pea. As a rule, these lapilli-like granules are small;

* My colleague, Mr. C. Hackct, has been working at these rocks near Gwalior; and it was from comparison with his specimens (mottled and speckled granulated shales) which are generally much more clearly "ashes" than my mottled shales, that I was confirmed in the idea that the flaky shales of Tâdapurtee valley must have been "ashes" or fine volcanic dust.—W. K.

See Records, Geological Survey of India, Vol. III. 2. 1870.

† Otherwise, they are of all degrees of compactness.

and they are not always clearly distinguishable as separate bodies in the mass of the shale, but seem to run in with the flaky layering.

They are always well bedded, and occur throughout the series from the lower traps up to above the higher flows. There is no arrangement of them in separate bands, they occur in rapid succession and shade down or up into ordinary shales without a trace of the granular or nodular structure; having sands and silicio-felspathic bands frequently intercalated with them. They perhaps show strongest in their granular structure when in close proximity with the flows of greenstone. The more minutely nodular varieties are often flaky, and resemble some of the 'ashes' described as occurring among the Silurian rocks of Wales.* Ripple marks are occasionally common among the more flaggy beds of these shales.

The best localities in which to see these supposed 'ashes' are at Beddadoor hill, on the left bank of the Chittravutty, or in the neighbourhood of Cauvarysamoodra, four or five miles north of Taudapurtee. In Biddadoor hill,† a few of the beds (cropping up near the base of the western slope) are quarried for a finely speckled red, green, yellow, and dark colored shale, which is quite greasy and soapy to the touch, and soft enough when dug out to be cut with a knife. This is a more compact form of these beds.

The lapilli-like granules are generally of a darker color than the rock itself, most frequently dark green or nearly black in color. On careful examination, with a magnifier, of freshly fractured surfaces, the granules are found to be

Possibly 'ashes.'

* See Memoirs, Geological Survey of Great Britain, Vol. III, pp. 64, 81, 93, 112, &c.

† Captain Newbold gives an account of this hill in his "Notes, principally geological, across the Peninsula of Southern India," (Jour. As. Soc., Bengal, Vol. XIV, p. 410). He refers to these spotted shales, and has called the variety worked by the stone-carvers in the village "Figure stone." He notes also the intrusive character of the trap in this hill.

The carvings made at this village from the spotted talcose or rather steatitic stone are very good, and the color of the stone is pretty; but the weight of the material is too great, except for small images, which are the favourite subjects.

somewhat rounded in form, though they are at times angular. Generally, they are rounded, and sometimes as it were segregated in irregular spindly and nodular forms. As a rule, the matrix and the granules are of a dull clayey appearance, but freshly broken and internal surfaces are sub-crystalline. When crystalloid, the rock is then seen to contain apparently worn* crystals of chlorite, felspar, and carbonate of lime. The crystals are, however, more generally sharp in their outline. It occasionally happens, when the shales are well weathered, that some of them do show that their spotted appearance is due to the presence of minute angular and roughly rounded fragments of chlorite and other minerals different from the matrix of the rock.

An average specimen of the more typically granulated shale gives the following composition† :—

Loss by ignition	3·5
Silica	57·81
Oxides of iron and alumina	31·25
Lime	0·74
Magnesia	0·25
Potash	0·08
Soda	6·04
	99·67

The particular variety here analysed is a thin-layered flaky (flaky when worn, much more compact in the specimen now preserved) coarsely granulated rock of a general dark brown purple color. When examined with a magnifier, it is seen to be made up of irregular rudely ellipsoidal granules of nearly black or dark green color, in a matrix of pale purple clayey material. The granules are, however, so close together that the

* So much alteration was superinduced on these rocks, not only at the time of their deposition when they were overflowed and intruded on by greenstone, but subsequently when the general metamorphism of both KADAPAHS and KARNÚLS took place, that it is hardly possible that these crystals could show any worn appearance. Even their present shape and constitution may all have resulted from influences long subsequent to the period of volcanic action now indicated in the series.

† I am indebted to my colleague, Mr. A. Tween, for this analysis.

pale purple clayey material appears to be in lapilli too. The rock weathers of a reddish brown color mottled with paler spots, and its deposition-surfaces are roughened with the granules. The specimen is from a thick band of these shales at the base of a low hill due north of Taudapurtee.*

Concretionary shales.

The finer-grained and more compact shales, with distinct spherules or ellipsoids of a like constitution with the mass of the rock, are more clearly concretionary in their structure than the speckled and granular flaky varieties. In some cases the concretions are more compact and of a darker color than the matrix in which they lie. There is one case of a few bands of calcareous shales which are concretionary in a much larger and more irregular way; the nodules being calcareous, compact, and sub-crystalline; they crop out in the irregular hilly country below the south side of the Oopalpád plateau, and some eight miles east of Yadakee, whereabout the finest show of contemporaneous and intrusive traps, with associated shales, sandstones, speckled and granular shales, and chert-like bands of petrosilex, or compact felsites, is to be seen. The stream from Goodypaud to the north, after flowing for some time along the edge of the upper terrace of KARNÚL rocks, falls over the edge and cuts deeply into the subjacent Tâdapurtee slates, &c. There must be more than half a mile of shales, ashes, and felspathic bands exposed in the course of this stream, all of which are dipping regularly at 10°-20° east or east-north-east, above and below which are flows of trap. It is about the middle of this set

* While referring to this locality, it is as well to give an instance of the peculiar changes which occasionally take place in the character and appearance of the trap rocks. A few miles north of this hill, near Cauvarysamoodra, there is a quarry opened close to massive greenstone. A portion of this trap, at the time of my visit, was weathered into a very fine grained mud-stone of dark green color, which broke up in sub-angular fragments, so soft and crumbly as to be carried away with difficulty. A fragment of this is now in the Geol. Surv. Museum, Calcutta, which is quite hard again, and not to be broken at the edges by the pressure of the fingers. In the field, if there had not been the massive rock close by, the weathered mass might have been called a volcanic mud.—W. K.

of rocks that the largely nodular bands occur: they are very thin, only a few inches, like nearly all the other beds of shales.

Band of ferruginous chert beds.

The next band of rocks worthy of attention among this series of slaty shales is a ferruginous set of shales, silicious chert-like bands and sands, which occur low down in the series between two of the most marked trap flows.* These ferruginous beds are again very similar to others in the Gwalior rocks of Central India. The northern extremity of outcrop is in the hilly country below the western slopes of the Oopalpád plateau, just at the edge of the terrace of *Banaganpilly* quartzite. Thence, it strikes with a slight curve past Yadakee, south-south-east to the Chittravutty river, and so to the Cuddapah basin, curving round parallel with the Paupugnee river, where it is again covered up by the KARNÚLS of the southern end of the Nundial valley. The rocks show clearest from the Chittravutty northwards, being for many miles dark brown ferruginous shales, with now and then thick beds of sandstone, and banded or striated beds of cherty and compact silicious rocks. The shales are hard, somewhat porcellanic, much given to breaking up in thin jointed fragments; and are often replaced by brown ribboned jaspers or cherts. The uppermost shales and sands are rather red, and in some parts of the outcrop there are again higher shales, not so ferruginous, with a few limestone beds.

The following analysis of that band of this silicious rock showing a tendency to split up in tolerably perfect six-sided prisms was made by Mr. A. Tween :—

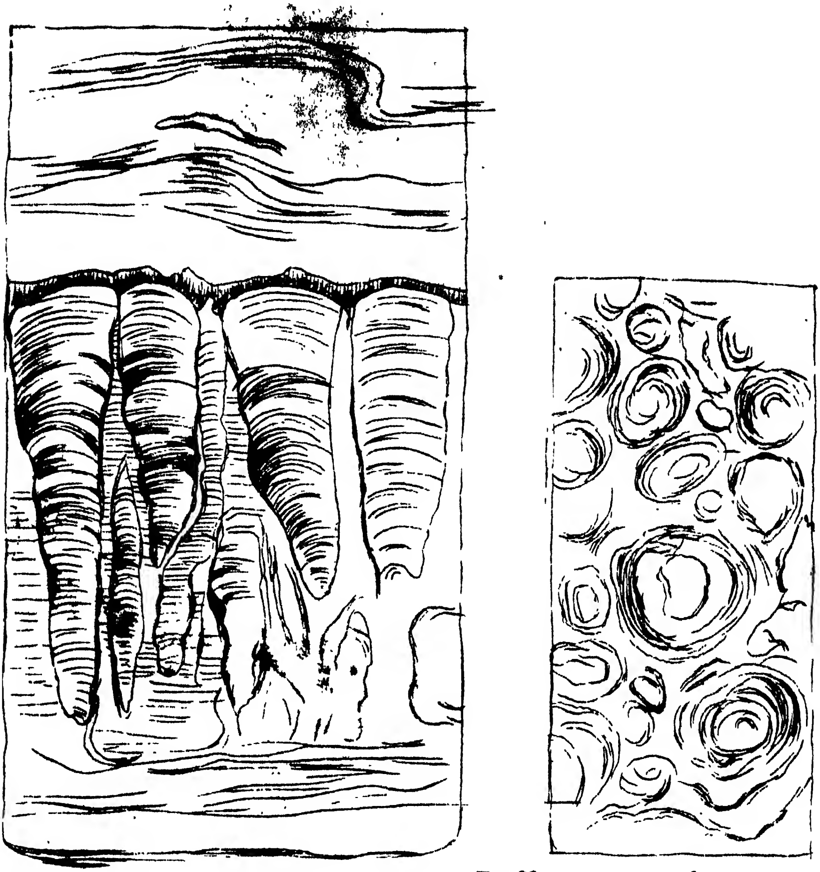
Loss on ignition	......
Silica	97·2
Oxides of iron and alumina	2·25
Lime	·8
	100·25

* Those striking through Polamuoda and Jootoor.

There must be very little iron in this variety of the rock constituting these bands. From Yadakee northwards, the band becomes somewhat more ferruginous, and the rocks are generally of a red color: while the laminated jasper beds, or beds of shale and chert, begin to show more particularly, until at the northern extremity of the outcrop south-west and west of Naradacherla, the series has become quite marked with red and brown ferruginous jasper beds, banded in red jasper, red hæmatite, white and dirty chert and coarser brown ferruginous cherty layers. The series is still between two flows of trap, as it appears to be throughout the whole extent of the outcrop.

Beds of limestones.

The lowest beds for the longest part of the outcrop, that is, from its first appearance in the Poolavaindla hills west of Cuddapah up to the neighbourhood of Ryalcheroo north of the Penn-air river, are essentially slaty and calcareous shales of pale, purple, and grey colors. The beds are more calcareous as they are followed upwards in the series, until the bands of limestone are reached. These bands of limestones are interesting, as they show, perhaps more than any others in the series, evident signs of alteration, probably brought about by the outpouring of the great flow which overlies them. They are generally grey-colored and finely crystalline, in thick beds, and are laminated and segregated in a peculiar way, with seams of amorphous silicious matter between the segregations. The laminæ are contorted, undulating or sinuous, which is not the case with the beds themselves: and these waving laminæ are always strongest towards the upper surface of the beds, and in the upper beds. The annexed figures are from one of the beds near the village of Soorapully in the valley inside of the great Jootoor flow of trap some eight miles south of the Penn-air; and the same band of limestones shows all the way to the south with very much the same style of segregation.



a. Fig. 29. b.

Fig. 29: *a* shows the appearance of the edge of a bed about 4 feet in thickness: *b* shows the upper surface of part of the same bed. Some of the concentric laminæ of the segregations are of well crystallized black carbonate of lime. The rest of the laminæ are silicious; and the rock weathers with these silicious seams or walls of the segregations standing out over the surface. In freshly broken parts of the rock the silicious laminæ are hardly recognizable. The thick seam of silicious matter capping the peculiar long purse-like segregations is partly granular with minute segregated particles.

Upper band of limestones.

At the base of the main line of Beddadoor hill, &c., the great flows of trap with their accompanying ashes and shales with silicio-felspathic bands are overlaid by a series of compact semi-crystalline limestone beds, which, to the south of the Chittravutty, thicken out and show well at the western base of

Condapoor range of the hills for from 20 to 30 feet in thickness. South-south-west of the village of Anantapoor, in the wider valley at the foot of the hills, there is a fine display of these limestones as they rest on a great flow of trap from 80 to 100 feet thick. The limestones appear to lie in regular succession in this flow of trap. They are of pale blueish-grey color, with well marked interlaminations of fine compact silicio-felspathic matter; these interlaminations becoming more numerous as the outcrop of the beds is ascended, until the calcareous element has ceased altogether. With the silicious interlaminations are also others of a green color, softer, and finely crystalline, with seams of a white zeolite in minute radiating fibrous botryoidal crystallizations. This set of limestones is immediately underlaid by greenstone, apparently quite conformably. As the calcareous element ceases in following the beds upwards, the beds are overlaid by about 50 feet of reddish-brown claystone beds, in which are also intercalations of the pale green crystalline rock with small botryoidal assemblages of zeolite: when over all comes a great thickness of very fine-grained and compact felspathic sandstone of grey and dark-green colors.

This band of limestones is very persistent, with very much the characters, for many miles to the north and south from the same Chittravutty outcrop; though it is largely covered up to the north after reaching the Penn-air river, a few miles west of Talapodatoor, until it again shows very strongly in the next decided outcrop of the same traps east of Yadakee, and below the south side of the Oopalpâd plateau.

Silicio-felspathic bands, or felsites.

So far, the rocks of this group are ordinary aqueous deposits, with the exception of the flaky shales just described. There is, however, yet another variety of stratified rock, which is even more difficult to account for, except through volcanic agencies, than the mottled and flaky shales.

These are compact, very fine-grained, thin chert-like beds, of which three average specimens of different bands gave the following composition :—

	No. 1.	No. 2.	No. 3.
Loss by ignition	1·4	0·3	1·3
Silica	31·65	83·22	79·65
Oxides of iron and alumina ...	11·55	11·25	16·25
Lime	trace	·83	1·45
Magnesia	......	......	......
Potash	5·22	·04	·24
Soda	0·53	4·95	5·81
	100·35	100·59	100·70

Specimen No. 1 is a compact, very fine-textured, amygdaloidal, porcellanic rock and seems to be an orthoclase felsite. Its composition agrees very closely with that of *leelite* and other felsites of this family given by Dana in his System of Mineralogy (1868).

No. 2 is a fine grey, compact, chert-like, porcellanic rock.

No. 3 is a reddish brown, not so fine-grained, chert-like rock, speckled with dark green spots.

Both these specimens are, according to their composition, oligoclase felsites, and answer to analyses of those given by Dana.*

These silicio-felspathic bands are more like thin beds of chert than any other rock; but their peculiarly close association with trap-flows and their occasional igneous look, besides their answering in appearance to a certain extent to what are called felstone, felsite, or petrosilex by petrologists, led at length to the consideration that they could be nothing else but felsites. Further examination of these rocks with the blow-pipe by Mr. F. R. Mallet of the Geological Survey of India, has also, to a great extent, confirmed the supposition of their volcanic origin, while the foregoing later analyses of Mr A. Tween are in favor of this view.

* Dana's System of Mineralogy," Fifth Ed. (1868), pp. 347, 351, 358.

These chert-like rocks are of various shades of grey and brown colors: they are exceedingly hard, scarcely, in some instances, to be scratched by the knife, very compact, and very fine-grained. They break with a semi-conchoidal or hackly fracture in splinters with a sharp and acute edge. The finer varieties show a surface of fracture like that of coarse porcelain; and they are not, except in rare cases and when the rock is weathered, acted on by acid. They are all fusible with great difficulty before the blow-pipe. The darker varieties weather of a white color to an exceedingly slight depth from the surface. The thicker beds or bands break up in joints sometimes just like trap, that is, in pillars with an irregular polygonal section. They are all more or less laminated, or seamed with laminæ, which are parallel to the stratification of the rest of the true aqueous rocks of this series. There is no instance of intrusion of these rocks: they all seem to have been regularly spread out over the subjacent strata in thin seams.

Amygdaloidal.

One of these seams is amygdaloidal with kernels of calc-spar, and it was mainly the structure of this particular band which tended to the conclusion that these deposits are not cherts but felstone or hornstone. The variety* in question is a fine-grained, compact, porcellanic pale grey rock, peppered over with minute black speckles, and amygdaloidal with spherical or rather small bean-like assemblages of darker grey glassy calc-spar. The kernels weather out, leaving distinct and well-marked cavities.

This is the only band of these rocks which is vesicular; and whether it be a consolidated felspathic dust, or a contemporaneous flow of felspathic lava, it is very much of the same composition, except in the small quantity of soda, as the other grey beds.

The term felstone is usually applied to an intrusive rock, but it is used also by the Geological Survey of Great Britain for rocks which are as

* No. 1 of preceding analyses.

clearly bedded as those now referred to, and with the idea that it was poured out as a lava, or that it may be a consolidated felspathic dust.

It is most difficult to conceive how the rock constituting the beds in the Tâudapurtee valley could have been poured out under water as a lava over several square miles, in such a state of liquidity as to give the thin strata now exhibited, varying from less than a foot in thickness up to three or four feet: and yet there are indications of such an origin in the rather thick bed of amygdaloidal felstone already referred to, cropping out along the base of the western Oopalpád slopes. The sub-aqueous origin of the felstones is very apparent in the extremely regular inter-stratification with the sands and shales of this group, and in the general and almost total absence of vesicularity. Had the deposition of the felsites been sub-aërial they must have been more generally vesicular as also more unevenly surfaced.

Under the view that the rock was originally a dust, one might expect to find some traces of fragmentary structure in a bed thus derived; but throughout the field there are only the faintest traces of such, as for example, in the spotted appearance of specimen No. 3.*

Have produced no apparent alteration in contact beds.

There is no apparent alteration of strata subjacent to these felsites. Indeed it is difficult to recognize this even under the great flows of greenstone, for they are generally resting on shales which show no other effect than that they are harder perhaps than lower beds and more clearly jointed, or cleaved. The thin beds of sandstone are sometimes waved in their lamination beneath the great flows of diorite; but these were evidently much more powerful in their influence than such thin flows of felsite (if these were lavas) could be.

* It has been suggested to me by Dr. Oldham that the rock may have been originally a volcanic mud, and this seems very possible, and even more in accordance with subaqueous deposition, as the mud would be more liquified and thus be spread out over a wider area.

Further investigation of the country by future explorers may eventually show that these interesting bands of rock are partly intrusive, just as is the case with the hornblendic traps; but as yet there is no satisfactory instance of this. There is plenty of room for the discovery; it was utterly impossible that the numerous bands of this rock cropping up over the country in rapid succession amongst countless beds of shale, could be followed out for their whole distance. Besides, even the more decided bands, which are seen at a distance for many miles as white lines on the slope of the hills, are every now and then dying out and appearing again, and in such cases it is quite impossible to say whether they continue to run exactly between the same beds.

These bands of felspathic traps have, like the hornblendic flows, been stronger at two different periods; high up in the group, associated with the upper traps, and again low down in the lower flows. But it would seem from the prevalence of outcrops along the lowest slopes of the northern part of the Gundycotta range and of the western part of the Oopalpád plateau hills, that the volcanic ejections were then more felspathic in their constitution than was the case at the time of the pouring out of the more westerly or lower flows of hornblendic trap.

It is unfortunate that the map was not on a sufficiently large scale for the delineation of these bands; but they are so numerous, and yet so thin of themselves, that this could not be done. On the other hand, the limestone bands occurring in this group of rocks are, though not of any great thickness, still few enough to be represented; and they are of sufficient industrial importance to necessitate this.

Trap flows.

The next peculiar and most striking feature in the Tâdapurtee slate series, and which is not seen in any other of the numerous slate groups of the KADAPAH rocks, is the presence of two bands of great trap flows, which crop out along the whole extent of the field between the Paupugnee and Kistnah

rivers. These flows are generally contemporaneous with the other deposits of this sub-group, but there are every now and then cases of intrusion. The sheets are with the stratification, rarely across it.

Character of rock.

These greenstones or diorites are generally coarse-grained and massive, and of dark colors, one or two of the flows being finer, more compact, and of grey or pale green colors. There are instances also of a flow being in one place coarse-grained or largely crystalline, of a dark green, or mottled shades of green, while at other places it is a fine-grained, grey, or pale green rock. In rare instances the rock is porphyritic, with large pale green crystals of felspar. The trap of one flow (Jootoor), on the left bank of the Penn-air, contains *olivine*.

These traps weather of a very dark brown or black; but there is one flow in particular, the largest, which weathers in its upper half of a warm brown color, and in its lower of a deep black brown. As a consequence of this last character the outcrop of this flow—owing to the upper part being still left here and there along the crests of the ridges, and there being trains of debris from these remnants—often presents the appearance of the blacker trap being as it were crested by, and seamed with the roots of, another and intrusive trap. Some of the flows show more particularly the spheroidal form of weathering; while the generality break up in a massive cuboidal manner.

Contemporaneity.

The contemporaneous character of the flows is well seen over the greater part of the area, in the marvellous parallelism of their outcrops with those of the shales, sandstones, and limestones underneath or above them, as they strike along the slopes of the different hill ranges and ridges in this western part of the country. Our maps will even show this; and it is only to be regretted that they are on so small a scale, for rarely is a country so cleanly cut up and exposed as is that under examination, particularly to the north below the Oopalpád plateau.

There are, of course, examples of extreme obscurity: as for instance, where there are clear cases of displacement of beds by faulting, or where intrusive trap shows; or, again, where there has evidently been some considerable local denudation of the upper surface of a flow prior to the deposition of the overlying shales.

Two periods of volcanic energy.

The number of these flows of trap varies, as some of them thin out in shorter or longer distances within the outcrop of the whole group; but there are four or five which are tolerably persistent all through. The strongest flows are low down in the series. In fact there seems to have been two periods of volcanic energy: the first and strongest early in the formation of the series; the next, much less extensive and about two-thirds up in the series.

Early trap intrusive.

Even at the very commencement of the formation of the Tâdapurtee slates, volcanic forces were in action; and the trap was then intrusive, for it has penetrated and overflowed, as already related, the beds of both the Poolavaindla (Naggery) quartzites and Vaimpully limestones below; and has even flowed beyond the edge of the KADAPAH rocks in their northern area, and touched on the CRYSTALLINES or GNEISS rocks.

The thickest flows are, as far as can now be made out, from two to three hundred feet thick in their fullest outcrops; but this is doubtless not their greatest thickness, and it is not now possible to ascertain accurately what that limit was, owing to the denudation which has since gone on, and the generally hidden state of the junction of the upper surface with the beds above. The lower surface and the rocks immediately subjacent are generally quite clearly exposed, the outcrops of the traps themselves forming well defined scarps along the western faces of the ridges, while the lower beds are seen on the slopes below.

Lie of traps with other strata.

This gentle dip is not, however, preserved throughout; southwards, *i. e.*, in the wide flat country (only diversified at intervals by long low ridges) to the west of

Cuddapah and south of the Gundycotta range, the lie of the beds is very low, and the rocks much covered up with recent deposits. Northwards, the traps, just as with the other beds of this sub-group, are gradually tilted up at higher and higher angles until they reach their maximum inclination in the Puspulla valley.

Intrusive aspect.

The intrusive character of some of the outcrops of trap is tolerably clear in many places; but it is very often difficult to make out in the same localities what is not intrusive, or indeed whether the eruption has been contemporaneous. The long and uniform lines of outcrop, and their position for long distances between other well marked bands of aqueous rocks, are great points in favor of the contemporaneous mode of formation; but there are examples every now and then when one finds these so well defined lines ending abruptly or thickening or thinning out rather sharply into one another. These last irregularities can, however, be explained away by the fact that different flows of trap may have come in juxtaposition through the thinning out of intervening aqueous deposits.

Flows tailing in over one another.

There are frequent cases of this last mode of deposition, as on the Jillalupenta hills, below the western slopes of the Oopalpád plateau, where there is rather an extensive intercalation of slaty shales with felstone bands, between trap flows; at either end of the intercalation, the great outcrop of trap appeared to be all one. Again, in the trappean outcrop south of the Oopalpád plateau, there are two or three examples of the same kind, in addition to some intrusion of trap and faulting. The uppermost continuous outcrop of trap, or the Polamuoda flow, shows also, between the Penn-air and the Chittravutty, many examples of intercalated shales, &c. And, lastly, there are some examples of the same kind on the right bank of the Chittravutty, south-east of Beddadoor hill.

Intrusion is most distinctly evident in the small bay below the southern flanks of the Oopalpád plateau, where the numerous outcrops,

apparently of contemporaneous trap, are connected through a thick series of shales by dykes, thus apparently joining one another. Now and then, at certain points in all the flows, there are cases of the trap seeming to cut across the beds at very acute angles; these crossings are never very clearly exposed, the contacts being so commonly covered with debris; but there are at times well marked bands of limestone, or of other rocks, which at one part of the outcrop are underlying a certain trap-flow; and then again further north, or south, the same kind of beds are above the flow, while there are still some below.

In this intrusive area, the bursting through the strata is best seen in the stream* flowing down from Goodypaud and Jaidwangoopully, where it traverses the rather lofty ridge of the Chintamanpully hills. About east of the latter village, the stream has cut well into the rocks, and in this ravine, near an old pagoda, there is a fine example of a 50-feet wide dyke of trap cutting up through the shales, and so joining a great flow which overlies them. On the western slopes, too, of Chintamanpully hill, there are several outcrops of trap which are not parallel to the stratification, and against which the shales are abutting. Some of these abnormal, or rather intrusive, appearances of the trap are probably not real, but owe their seemingly abrupt cessation to the covering of fallen debris. There is no doubt, however, that there are dykes cutting up through beds of shales and so causing a connection between different flows. The flows, too, are very irregular in their thicknesses; and at the northern end of these hills, a good many

Faint indications of volcanic centres.

coalesce into one very large flow just below Coondanacota. Indeed, it seemed that if there were any point in the district where evidences of a centre or centres of volcanic outburst might be seen, that it was here. There is undulation

* This stream is wrongly represented on the map in every way, the junction is a mile south of Jaidwangoopully: and the united streams run out at Chintamanpully instead of, as is represented, at Nittoor.

in the strata to a much greater extent than anywhere else; there appears to have been some dislocation; and the traps are both intrusive* and contemporaneous.

Intrusive trap of Beddadoor Hill.

The traps of Beddadoor Hill on the Chittravutty occur in the same way; only to much smaller extent. This hill is made up of a splendid series of grey and purple ash beds (spotted shales), shales, sandy shaly flags, and a few bands of felstone with either one or two great flows of trap. The long eastern back of the hill shows a basement of trap overlaid by shales and ash beds up to the summit. But in descending by the path towards the village on the western side, greenstone is found cropping up rather quickly and suddenly from under the shales of the summit; in fact, appearing to cut up through them at rather a sharp angle, thus :—

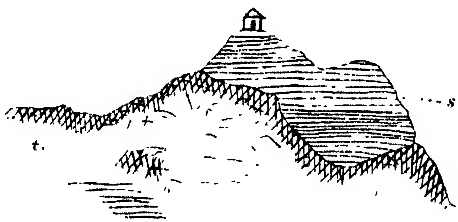


Fig. 30. Sketch section of summit of Beddadoor hill.
(t) Trap. (s) Shales.

To a certain extent, the shaly beds appear to merge down into this trap by sandy felspathic beds: elsewhere the shales are laminated close down to the massive greenstone, as though they had been deposited on an uneven surface of trap; while, again, in another locality, the trap seems to have cut right up against the beds, for the shales are contorted in their lamination close to the igneous rock. At any rate, the trap certainly overlies a great set of grey and purple shales with, near their

* I tried, by again and again looking over these outcrops, to account for the abrupt position of the trap, particularly up the ravine part of the stream, by faulting or by sharp folding, looking at the intrusions from all sides; but it was impossible to come to any other conclusion than that they were intrusions.

upper part, a 6 to 10 feet bed of compact grey trappean rock. The beds below are purple and dark green (speckled grey), laminated, ripple marked, flaggy ash beds; and then below these again is a great thickness of blue and purple speckled beds like those at the summit, and so by some sandy beds and shales to the bottom of the hill.*

On the southern slope of the hill, the trap again shows in such a way as to indicate that there must have been either intrusion of the trap and displacement of the beds, or that the trap must have been poured over a very uneven and denuded surface of the underlying rocks, after which the higher shales, &c., were in their turn deposited tolerably horizontally over an exceedingly uneven surface of trap:—

Fig. 31. View of the southern face of Bedda loor hill.
(s) Shales. (t) Trap.

The trap forming the east-south-east base of this hill rises up with an easy dip towards the summit. It rests conformably on grey spotted shaly and flaggy ash beds, with a sort of intermediate bed of

* It is worthy of note that there has been a large landslip on the village side of the hill, which has given rise to some confusion in the bedding. This landslip occurred within the memory of the present villagers; it did not cause any damage.

'ash'-sandstone—a grey felspathic sandstone-looking rock, which is not uncommon on this horizon of the group, further to the north. Below these shales, &c., comes another outcrop of trap. In following the base of the upper and main trap flow up to the ravine, or gully leading down to the bank of the Chittravutty from the summit of the hill, this base dips down sharply in a sort of saddle of the lower rocks, and rises up again on the other side of the ravine, as shown in the figure. The saddle-curve is not illusive, as though it were the section produced by the hollowing out of the ravine. The trap has either forced its way up across the edges of the lower beds, or it has been poured over a denuded surface or hollow in them. The ends of the strata are slightly dipping towards the hollow of the ravine.

The rock is an exceedingly coarse-weathering, large-grained greenstone. It weathers out in rough masses, the surfaces of which are studded with little rounded knobs, about the size of a large nut, of more coarsely crystallized trap, and the ground is strewn with these rounded bodies, as it were with the dung of sheep. On one side of the ravine there is a buttress-mass of shales and flags, against which the trap abuts. In working up the ravine the outcrop of trap is scaled for a couple of hundred feet or so to the upper surface of the flow, where it is a massive compact greenstone with a distinct wall-like outcrop, and is here overlaid by trappean muds which are weathering into a well laminated and bedded rock of a dark green color; and these merge into the spotted ash beds of the summit. The shales of the buttress on the west side of the ravine are well rippled and laminated. This trap is the same as that below the summit on the eastern side; and below the buttress of shales it is found, as shown in the figure, that the lower trap even comes in contact with the upper.

Looking at the outcrops on the western side of Beddadoor hill, it would certainly seem quite possible that this peculiar lie of the trap

might be due to denudation simply; only it should be a very abrupt form of denudation, especially on the south side of the hill. It would be strange how the shales of the summit could have been deposited so evenly from the bottom to the top of the hollow in the trap; though it is just as hard, on the supposition of intrusion, to understand how they could have remained so with a great volume of volcanic matter bursting up through them.

Considered generally, the traps are mostly contemporaneous, partly intrusive.

Taking then the stratigraphy of the whole of this sub-group into account, the traps certainly seem to have been only partially or locally intrusive, though much more so in their action on the subjacent Poolavaindlas and the group beneath them: while they were generally poured out contemporaneously with the deposition of the Tâdapurtee slates. Local intrusions are evident in the two regions above referred to, *viz.*, in the Beddadoor hill and to the east of Yadakee; and it may possibly be that these were near centres of ejection, traces of which are to be looked for in vain in any other part of the field; yet they must have existed somewhere, possibly in the neighbourhood, for there are no traces of trap beyond this region, except that of dykes in the crystallines outside, and these are not connectable in any way with the traps of the KADAPAHS.

The Poolumpett Slates with limestones.

Southern representatives of Tâdapurtee series.

The thin band, some 200 feet or more, of slates under the quartzites of Pollconda (south-east of Cuddapah) which, as stated in the last section, may be supposed to answer to the Tâdapurtee slates, is continued in its outcrop southwards at the base of the western slopes of the Pollconda range, and eventually spreads out in great force over the valley of the Chey-air in the Nundaloor* and Poolumpett† country. Here

* Nundaloor, a large village on the left bank of the Chey-air, near a station of that name on the north-west line of the Madras Railway.

† A cusbah or native Magistrate's village of the taluq.

it overlies the **Naggery** quartzites, and the only grounds for assuming that it is a representative of the beds on the Penn-air are, *first,* that both lie on quartzites which are only themselves possibly the same in different parts of the field;* *second,* that there is some petrological resemblance between the two; *third,* that they are overlaid unconformably in each region by a set of quartzites; and *lastly,* that if the whole series of KADAPAHS be traced downwards from their uppermost beds, as they are now being described upwards, it is found that the succession of strata in the various parts of the country lead to the same conclusion, *viz.,* that the **Tâdapurtees** are the same as the **Poolumpetts.**

Character of strata: Clay-slates and limestone.

Both in the Chey-air basin and in the Tâdapurtee valley this sub-group is a series of slates with limestone intercalated. To the south of the Chey-air, or in the valley of Poolumpett, after which town the series has been named, it is a thick group of grey and brown clay-slates, largely seamed with beds of generally compact silicious limestone, which are arrangeable in two bands. These seams are thicker and more frequent towards the Chey-air, decreasing in thickness southwards, until, in the isolated patch at the extreme end of the field, there are now no traces of limestones at all. Denudation may, of course, have had to do very largely with this absence of limestone bands to the south, but it is very evident that there was also originally a thinning out of these deposits to the southward.

In the Balbapully, or southernmost patch of the **Poolumpett** beds, the rocks are principally brown, grey or purple clay-slates, much cleaved and jointed, and lying in a tolerably regular basin, on the bottom quartzites. From this they roll sharply up to the east, and then down again over the southern spurs of the Yellaconda range, the rocks of this part of the range being mainly **Naggery** quartzites, while the

* I think it is almost quite clear that the Poolavaindla quartzites and the **Naggerys** are the same.—W. K.

bands of slates seen in them are representatives of other thin bands in the western scarps.*

After crossing over the watershed of quartzites north of the Balbapully patch of slates, the same strata are immediately found in the valley beyond, *viz.*, grey and brown coarse clay-slates, much cleaved and breaking up in jointed ridge-shaped masses. They are traceable round either side of the widening valley, but are much covered up in the middle by superficial deposits.

Upper band of limestones.

The Toonooconda hill-ridge, west of Codoor, soon gives a clear idea of the higher strata; for, at the base, or not very far above it, the bands of limestone begin to come in, and thence northwards they are to be seen very strong over the middle of the valley, and dipping down under quartzites of the Chittavail ridges. The beds are undulating, but dip, on the whole, at low angles to the eastward, the Toonooconda ridge and Wattaloor hill further north being in the axes of large shallow synclinals.

Lower band.

There are lower bands of limestone than those of the bases of these two hill-ridges, but they are very thin and apparently more extended further south than Wattaloor Conda. It is very difficult to make this out clearly, for the dip of the strata, both quartzites and slates, is so low to the west of Wattaloor, and the country up to the bases of the quartzite-formed sides of the basin is so flat and so covered up with superficial deposits, that it is impossible to trace the limestone-outcrops, if they ever existed, further south with any continuity. At first sight, the lower outcrops of limestone do not appear to run parallel with the quartzite edges, but seem, if they could be followed out, as though they were striking southwards into the gentle slope of the western hills. On this view there seems

* It requires close examination to make out the lie of the beds here; both Mr. Charles Æ. Oldham and I were for a long time under the impression that the slates of the Balbapully valley dipped under the quartzites of the Yellaconda.—W. K.

some ground for an unconformity between the two sub-groups, but further evidence of this was not obtainable.

Sands, flags, and cherts.

There are numerous thin bands of fine quartzite-sandstone, more flaggy beds, and very fine-grained thick-bedded calcareous sands and coarse cherts, associated with the slates at various levels in the series; but these are more particularly in juxtaposition with the limestone beds.

Ferruginous quartzite.

Ferruginous beds of quartzite are also common, the iron of which is sometimes very abundant, and is smelted in some localities. Yerragoontla Cotta is an iron-smelting village; but here the iron (magnetic iron-ore) is mainly obtained from the quartzites to the west. There is a good deal of pseudo-laterite, or lateritic conglomerate and breccia, spread over the Yerragoontla and Codoor plains, which evidently derived their iron from the ferruginous bands in this group, both slates and quartzites.

Lie of strata to the east obscure.

In that part of the Yellaconda range to the east of Codoor there is a good deal of obscurity as to the lie of these Poolumpett slates. They overlie the quartzites of the range south of this, or, rather, they once rolled over them into what is now the Nellore country. But they clearly must underlie the strata of Nagwaram hill-mass and those of Venkatigherry Droog. Mr. Charles Oldham's sections indicate this; and he notes that the main mass of the western part of Nagwaram hill is of slates, with only a few bands of quartzites, and a thin series of the latter capping the higher parts of the mountain; so that the greater part of these strata must be of the superincumbent group. The Koyamon Conda, south of the Venkatigherry pass, is part of the rim of a dome; the rim, or Koyamon peak and its continuation into Cossy Conda, being of quartzites which underlie the Poolumpett slates.

The eastern outcrop of these slates must then have cut across the Yellaconda ridges in the neighbourhood of Venkatigherry Droog.

We could not, however, certainly recognize those slates; all the different bands which appear on this part of the range being much undulated and altogether more schistose than any of the beds in the flat valleys to the westward.

Eastern line of faulting.

The dome-shaped arrangement of the Koyamon Conda was to some extent cut off by faulting, for, as will be seen on the map, the gneiss occurs right up against the quartzite of the eastern base of the ridge.

Character of limestones.

The various bands of limestone are generally more or less silicious as also magnesian, and to some slight extent are of grey colors, though there are exceptions to both these characters; as on the north or left bank of the Chey-air, where they are often red and purple earthy limestones, with thin compact and grey beds, lighter-colored than generally occur to the south. We did not observe any traces in the Chey-air basin of those oolitoid silicious bands which are so common in the Vaimpullys, and which at first sight might be taken as the northerly extension of this sub-group.

The outcrop of Poolumpett slates in the western slopes of the range of hills enclosing the western side of the Ontimitta valley, are principally red earthy and sandy deposits, with, towards the Cuddapah end, a good thickness of purple clay-slates. The limestone bands in this outcrop are very thin, and finally disappear almost entirely in the western slopes of the Pollconda. The band is comparatively thin here, and shows very well above the flat terrace overlooking the famous Pedda Gaudee cataract* south-south-east of Cuddapah town.

In the western slopes of the Pollconda the outcrop of the Poolumpett beds is completely discontinuous with its representatives further westward in the Tâdapurtee valley; but when these are reached, there is the same thin outcrop of pale red earthy and sandy beds with

* A wild and picturesque rift cut by the Boogoo river in the vertical cliffs of a great bay which has been denuded in the lower quartzites of the Chey-air series.

clay-slates and bands of limestone, which are, however, there associated with the trap-flows already described.

Breccia-limestones.

Before leaving the Chey-air field, it may be as well to notice a few more particular features of some of the limestone beds. Among the lowest of these in the series there are some very peculiar breccia beds of light grey limestone, which are perhaps best seen a mile or so south-west of Reddypully. These breccias are most extraordinary in their crowded fragments of pale blue-grey compact limestone of every size, from small pieces to blocks of two or three feet in diameter. The fragments are of laminated limestone, and, to a certain extent, are arranged laminarly in the limestone matrix; that is, in addition to any laminar arrangement which this debris may have assumed in deposition, they seem to have been stretched with the beds and so to have obtained an attenuated look. It is difficult to account for these breccia layers, very much in the same way as it is difficult to account for the evenly stratified breccias of the *Jummul-mudgoos* in the KARNÚLS; for, without any apparent disturbance in the strata of limestone subjacent to the breccias, it is unaccountable how such rough materials could have been carried along by the water unless they had denuded the surface of the calcareous deposit on which they are resting. It is conceivable that the lower layers may have been to some extent solidified, and that the debris of the breccia was thrown or brought suddenly into deep water through which it settled down quietly on the previous layer. And yet the breccia beds are thin and spread out over rather large areas in tolerably uniform beds; and not heaped as would at first sight seem to be the result of a sudden influx of angular debris. The beds are, however, evidently local, both in their extension and in their thickness. The interstices are often filled with fine sand. There are sandy layers among the beds, and towards the top shaly strata, while over these come brown sandstones (quartzites) in thin beds.

The metamorphism to which these rocks were subsequently exposed may, on the other hand, have had some influence in obliterating any effects which the forces necessary to carry this debris might have produced.

Again, the source of the debris may have been calcareous muds which were deposited in very shallow water, not far from the localities in which we now find the breccia layers; these became sun-dried, as we see the thick alluvial deposits in rivers* and tanks of India now-a-days, and thus broken up into fragments which were eventually carried off by the next floods. There are, at the present time, examples of this breaking up of calcareous mudstones in the course of the Khoond-air river. Some of the Nundial shales over which it flows, particularly about the course between Cuddapah and Chagulmurry, are perfect mudstones, as recent-looking as any hardened mud deposits formed at the present time in the same river. These become cracked up by exposure, and if not carried away, the fragments are at every fresh covered up by a more or less red calcareous mud, which is derived from the beds of the very same rocks. Were these examples sufficiently extensive, or allowed to remain, instead of being annually washed away, there would then be a calcareous breccia not at all unlike those of the lower part of the Poolumpett slates.

Peculiar silicious beds.

The next peculiar variety of limestone in the Poolumpett beds is a very hard, dark grey and weathering nearly black, silicious rock, which often in its appearance and mode of occurrence looks like an intrusive igneous rock!† The irregularly

* Along the banks of the Kistnah river there are numerous deposits of alluvium left every year for some distance up the tributaries, and these when sun-dried break up into great fragments two or three feet in diameter.—W. K.

† Mr. Charles Oldham was equally struck with me, years before I had an opportunity of close examination, by this strange aspect of an otherwise aqueous rock. He says, referring to this variety of the limestones near Nundaloor: "The blue impure silicious limestone which forms a considerable part of the low hills north-east of Nundaloor has very much the appearance, which I have noticed in the same beds elsewhere, of having been forced up among the slates."

furrowed and occasionally scoriaceous exposed surface is evidently due to the silicious laminæ running through the rock being left by weathering; but it is strange that the old surfaces on which the slates were deposited were often as irregular. In the latter cases it is frequently coralloid, but we could never find any traces of organic structure. Broken surfaces generally presented an extremely wavy laminar structure.

The strange feature about these ribbed and rugged-surfaced masses of limestone is that they only occur at intervals where the rock is most massive sub-crystalline and compact; and then the bedding is irregular, not uniform and even, as it is in the intermediate spaces of outcrop, while the outcrop shows a humpy form, thus:—

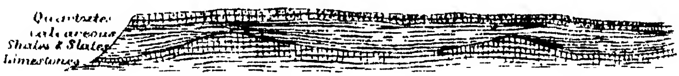


Fig. 32. Diagrammatic view of the outcrop of limestones along the western slopes of the middle ridge of hills south of the Chey-air, representing a length of about four miles.
(*l*) Limestone. (*s*) Shales. (*q*) Quartzite.

Signs of unconformity.

Between the humpy or lenticular thickenings of the limestone band, the beds are much more earthy. It is unfortunate that no clear section could be found showing whether the superincumbent slaty shales are actually unconformable on these limestones, but in all cases the junction was more or less obscured by debris. Occasionally, however, grey surfaces of these limestones are exposed, with some of the slates still undenuded, and these are lying in hollows and rifts of the lower rock, only here again it is not absolutely certain whether these hollows and rifts are not due to a contorted surface which might have been produced when the rock was in a pasty condition. On the whole, the rugged surfaces covered by slates seemed to be partly the result of denudation. It

must likewise be remembered that different bands of the superincumbent beds come directly on the limestones, as slates at one place, and sandstones, which are higher than these slates, in another locality. At the same time, denudation has not been the only agent at work in this anomalous form of outcrop, for there is the fact that the limestones are different in the humpy parts of outcrop to what they are in the longer generally uniform parts.

Coral formation might account for these humps, only there is no visible evidence of this mode of structure.*

Bedding is distinct, though it is irregular; and on this account there is some resemblance to deposits from intermittent silicio-calcareous springs; such sources would also account in some measure for the localization of the abnormal beds of the limestone band. At the present day the outcrop sometimes gives, at a distance, the idea of a set of splintery travertine terraces having been formed at several points along the western slopes of the ridges; but of course this is the appearance only of what might have gone on if the scarp had been there when these lenticular widenings were deposited.

There is a wide spread of these silicious beds—though here they are more generally well bedded—on the high road from Cuddapah to Madras, some four miles south of the Chey-air; but the more irregular and abnormal strata are to be seen in the western slopes of the hill-ridges to the east of the road.

Similar beds in the Baukrapett Hill and of Cuddapah.

There is no representative of these peculiar limestones in the valley crossed by the Penn-air; but beds of identical composition and structure occur to the north of Ontimitta, and along the western flanks of the southern part of the Nullamullays. These are best seen under the fine Baukrapett hill, east of Cuddapah, where they are about as intrusive-

* There is decidedly much more of resemblance to coralline structure in the *Jummulmudgoos* of the KARNULS, but even here there is no internal structure corroborative of this.

looking a set of rugged and black silicious limestones or calcareous silicious rock as could be imagined. They are not intrusive however, and it seems impossible to get rid of their unconformity to the quartzites and slates which cap the mountain unless they were coralline deposits.

Possibly Poolumpetts.

These limestones and quartzites of the Baukrapett range have been placed provisionally in the next higher group, principally because there are as yet no sufficient evidences of dislocation to allow of their being Poolumpetts. However, the question is quite an open one; and certainly, as far as resemblance goes, the beds of Baukrapett Conda resemble those of the Chey-air series more than any of the Cumbums, to be described hereafter.

CHAPTER 4.—THE NULLAMULLAY BEDS.

Byreneonda Quartzites.

The Poolumpetts are overlaid unconformably by quartzites.

The series of slates last described is overlaid unconformably by the quartzites of the Polleonda range, which set of rocks is traceable northwards for a good distance along the western flanks of the Nullamullays, until just opposite Nundial, when their outcrop turns eastward and appears as the summit of the highest mountain* in the Kurnool District, Byreneonda,

Of Byreneonda mountain.

which is on the western side of the Cumbum tanks. From Byreneonda the outcrop turns sharply south for some short distance, and then turns north again, as the tank-bund ridge of quartzites at Cumbum, and is eventually lost in the east and west valley of Dorenall, or the Muntaral Cunnama.

Seeming representatives in the Kistnah Nullamullays.

On the north side of this valley there is again a great show of coarse quartzite grits, &c., which on some grounds would seem to be representative of this sub-group, for, when these are traced westward into the

* 3,500 feet above the sea. See Section No. 2.

Irlaconda range, they are found to overlie mottled slaty shales and traps which are identical with those of the Penn-air slates with limestones. On the other hand, however, when the Irlaconda beds are traced eastwards over the Kistnah range of mountains they are found to be overlying other and higher slates than these, while they show very obscure stratigraphical relations along the eastern half of the Dorenall valley. On this account it is perhaps better to leave the *Kistnah* beds for separate consideration further on.

In the Yellaconda mountain ridge.

To the east of Cumbum, these Byrencondas rise up again from under the slates, next to be described, in the northern part of the Yellaconda range :* and they are evidently represented further northwards by the lowest quartzites in the Vinuconda, Yipur, and Nakarikallu domes; and again by the lowest beds of the eastern scarps of the ridges running up to and beyond the Kistnah to Battavole or Juggiapett. At this point they are the same beds which have already been noticed as the lowest of the series on the north side of the Kistnah.

In the Gundycotta or Jummulmudgoo range.

In the western part of the passage of the Penn-air across the Cuddapah field, the Tâdapurtee slate series is overlaid unconformably† by the quartzites of the Gundycotta or Jummulmudgoo hills; and therefore these beds, though completely insulated on all sides, are very possibly Byrencondas also.

Character of strata in Polleonda range.

In the Polleonda range, south-east of Cuddapah, the rocks are coarse grits and sands, with lower beds of pebbles and conglomerate. They lie unconformably on the subjacent slates with limestones, but this unconformity is obscured greatly by the folding which was impressed on the whole series. In the

* And are, if there be no system of faults (see chap. 5) with inversion, likewise represented in the whole of the eastern face of the rest of this mountain ridge.

† The unconformity is exceedingly slight, the quartzites of the gentle north-east slope being only a little flatter than those in the higher part of the western scarps. But at the Cuddapah end of the range, the quartzites are seen to lie over different beds.

Pollconda range, flanking the Ontimitta valley, the quartzites are seen on the western steep slopes to be overlying slates with a thin series of limestones, &c., which must be the lower member of the Poolumpett series; while in the southern part of this range, or that flanking the north bank of the Chey-air, the same quartzites are covering slaty shales, &c., with limestones of the upper band.

They show along the summit of this lofty range of hills running parallel with the north or left bank of the Chey-air; while the subjacent slaty shales and bands of limestone crop out from underneath them with a general undulating north-south strike.

Kaukul Conda fault.

In their continuation as the Kaukul Conda ridge and its southerly prolongations down the middle of the Chey-air field, they are much folded, and have been let down in the Kaukul Conda* by a north-west south-east line of fault, which in the south-west flanks of this mountain gives the idea that the limestones of the Nundaloor valley are overlying the strata of the mountain. A section through this part of the country will illustrate this lie of the rocks:—

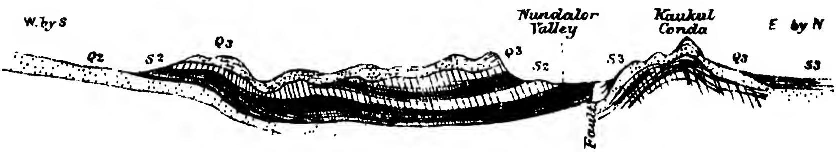


Fig. 33. Section through Kaukul Conda.

Q 2, Naggery Quartzites. S 2, Poolumpett slates with limestones.
Q 3, Byrenconda Quartzites. S 3, Cumbum slates.

It is unfortunate that the wide bed of the Chey-air obscures any further trace of the fault; its position, if it continues southwards, is not again recognizable except by a much closer search than time would allow us to make. The undulating aspect of the quartzites in Kaukul

* 2,125 feet above the sea.

Conda is much increased in the ridges to the south, where the great quartzite beds have been perfectly jammed up together; while there are considerable remnants of the superincumbent slates still left in the synclinal flexures.

In the Atchamapett hill, between Kaukul Conda and the east-west range to the westward, some very good examples of folding and slight inversion of the beds are to be seen. One case may be easily recognized from the north-west line of railway by any traveller in the train:—A very fine scarp of curved beds shows on the western face of the hill; and these may be seen in the little upland valley behind to be partially inverted before they roll over again and slope down eastwards to Conarazpolliam.

In the mid-ridges south of the Chey-air.

In the hill ridges south of the Chey-air, the lowest beds of these quartzites overlie slates with strong limestone bands; but they do so in a very peculiar way. Along the main ridge, they are generally lying directly on limestones, which, for some long distances, appear to be quite conformable with the beds above, and in this position are earthy and shaly; but at intervals these calcareous beds become strong, massive, and hard silicious beds, and they then form flat humps over which the lowest quartzite sands and thin sandy shales undulate, as though these irregular humps had existed previously to the deposition of the quartzites.

Unconformity.

At times, as on the eastern side of the village of Poly, the thin flaggy quartzites with sandy shales are lying directly on hard massive irregularly bedded limestone, which certainly seems to have been denuded before the sandstones were deposited. On the other hand, there are long outcrops of earthy limestone beds connecting the more silicious and splintery humps, and these, instead of being immediately subjacent to quartzites, are often overlaid by good thicknesses of shales and slaty shales, which are in their turn capped by quartzites apparently quite conformably.

The true state of affairs seems to be that the lowest beds of this quartzite sub-group are often thin shales, slaty shales, and sandy shales, which were first deposited in the denuded hollows of the Poolumpett slates. In this part of the field there is much folding in their ridges, and this may have frequently tended to exaggerate the thickness of shales, &c., between the sandstone strata and the limestone series: or, in other words, the shales would, in many cases, be crushed up into pockets in the sharp anticlinals and synclinals, and according as the rocks were denuded, the quartzite might be found at one time almost, if not immediately, in contact with limestones, and at another separated from them by a good thickness of shales.

Squeezed-up strata.

The squeezed-up arrangement of the quartzites with superincumbent and subjacent slates, &c., is very well seen in the broader belt of hill ridges between Poolumpett and Chittavail. There must also have been some faulting in a generally north and south direction, but the lines of fracture could not be traced out in the low country owing to the superficial covering of soil. In fact, except there had been fracture, it seems impossible to account for the abnormal position of the quartzites at the southern extremity of this series of ridges as they tail southwards towards Codoor, where they gradually appear to be intercalated with the slate of the Codoor country; while further north they are undoubtedly overlying them.

Southern extremity of the series obscured by faulting.

The further southerly extension of these quartzites into the Yellacondas about Venkatigherry Droog is not at all clear; or rather it is quite evident that they must strike into the range under the great set of slates of Nagwaram Conda; but it is as yet utterly impossible to recognize the sub-group with any certainty. There must likewise have been a sharp turn round in the strike to the eastward, as Konayon Conda appears to have been the nucleus of a great dome of the KADAPAH rocks, analogous to those north-north-east of Cumbum.

In the northern, or Nullamullay, extension the series is made up of thick-bedded coarse grits, with occasional pebble beds; while they are often very ferruginous* towards the bottom. They are exceedingly coarse white grits, weathering of a dark brown and not unlike some varieties of gneiss.† The higher beds as they appear on the more elevated ridges of the western side of the Nullamullays are often very compact fine-grained sandstone. The different passes across the Nullamullays give very good views of these beds, more particularly on either side of the range where they are seen to roll down under the slates of the central part. Occasionally there is a roll up again, and then the beds are seen in some of the higher ridges,—features which may be seen in many of the appended sections.

The Nullamullay field.

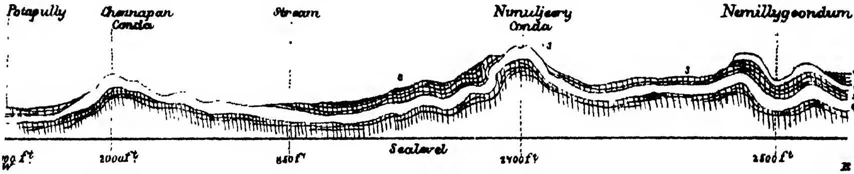


Fig 34 A

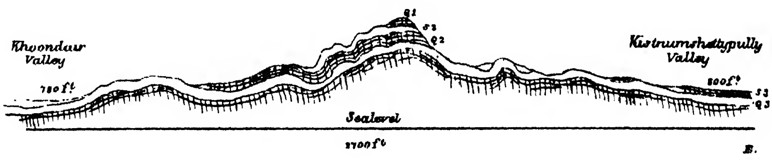


Fig 34 B

Fig. 34A. Nearly along the Cotta Cunnama, Nullamullays

Fig 34B. Section across the Nullamullays nearly in a line with, and slightly north of, the Nundycunnama Pass.

Q1, Nundycunnama Quartzites: S2, Aukiveed Slates · Q2, Nemillygoondum Quartzites: S3, Cumbum Slates: Q3, Byreuconda Quartzites.

Horl. scale, 4 miles to the inch. Vertical, diagrammatic.

The Yellaconda range is for its northern part, or from the watershed between the Goondlacumma and Suggle-air basins, mainly

* It is from these beds that most of the iron-ore smelted along the eastern side of the Khoond-air valley is obtained.

† This gneissoid appearance of the grits led me for some time to think that here might be the fundamental rocks of the KADAPAHS, and a form of passage into the older CRYSTALLINES. However, it soon turned out that there were plenty of quartzites and slates beneath.—W. K.

made up of these quartzites which Mr. Foote has examined and thus describes:—

The Yellaconda beds, Mr. Foote's notes.

"The Byrenconda quartzites occur in several detached areas of various shapes and sizes, of which there are four principal ones and several small outliers. The principal are:—The Byrenconda ridge with the Chellumconda and Cumbum tank-bund ridge; the Moaksheegoondum hills; the Unkalumma Condas; and the northern part of the Yellacondas. The outliers are the Gooral Conda, the Timapore outlier, and the western and central ridges of the Kullsapad hills.

"In lithological and petrological characters, the Byrenecondas do not differ from the Nemillygoondums;* and there is also a remarkable similarity in the several exposed areas of this formation however widely separated from each other. The most characteristic members of the group are typical quartzites, generally fine-grained and with waxy semi-vitreous lustre; but besides, there are beds with an admixture of micaceous scales in varying proportions. Other beds of lesser frequency show an admixture of argillaceous or talcose particles: sometimes, indeed, both are present, forming a talcose silicious schist which may or may not graduate, as the case may be, into slates. A few beds of true slates are here and there found among the great quartzite masses, but they are generally of trivial importance. A few of the beds contain grains of peroxide of iron sufficient to color them of a dark steel-blue or grey."†

Stratigraphy of the Yellacondas obscure.

The stratigraphy of the Byrencondas in the Yellacondas is very complicated; but here again, it is necessary to give Mr. Foote's own observations, more particularly as he was at the time of survey inclined to look on the southern extension of the Yellacondas as of the same group.

"The structure of the Yellaconda range must now be entered into and explained as far as possible. The great number of foldings of the KADAPAH ROCKS in the Cumbum taluq, many on a gigantic scale, fully indicate some still grander phenomena of the same kind in the Yellaconda range; and it is found that in many places there is ocular proof of huge foldings; while in many others only the assumption of such foldings will explain the singular relation of the formations which compose the mass of the range.

"The structure of the range will be most easily explained by giving a series of sections across it, constructed from observations along great part of the ridge, from the Sheetarampoor Ghat, opposite Porenaumla, to the Vamalapaud pass, near the extreme northern end of the Yellacondas. One of the clearest sections across the

* A higher series.

† There are some beds of quartzites in this group, though such are not confined to it, which are on weathered surfaces mottled all over with spots of brown peroxide of iron about the size of peas, though internally one cannot recognize any such arrangement of the peroxide of iron contained in the stone. The iron is finely distributed among the grains of the unweathered rock.—W. K.

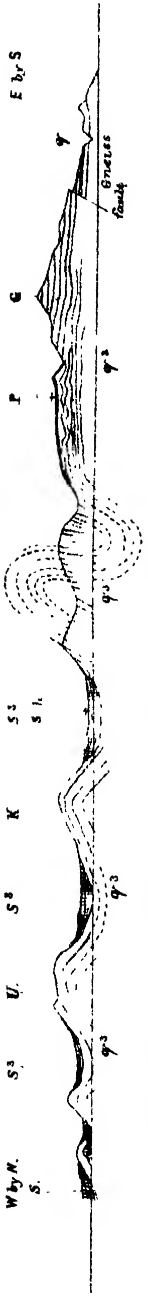


Fig. 35. Section of the Yellaconda range, a little south of the Gauly Conda peak.
S3. Cumbum Slates: Q3. Byreneonda Quartzites: Q. Bottom beds.
S. Sunjevapully: Sh. Shingasanpully: P. Pogulla: U. Unkalumma Conda: K. Konapully Ghat spur: G. Gauly Conda ridge.

Yellacondas is obtained by going up the ravine east of Shingasanpully and crossing the mountains about a mile south of the Gauly Conda Trigonometrical Station.

"The results obtained by examining that line of country, together with a westward extension of the section, across the southern part of the Unkalumma Conda, are given in the annexed diagram (Fig. 35). The mountains are here seen to be formed by a series of two great anticlinals and synclinals followed by a great number of lesser foldings which pass under the Gauly Conda itself.

"The westernmost anticlinal forms the great spur west of Shingasanpully, which lies in a valley formed by a great synclinal fold, the east side of the valley rising into the second anticlinal. The second synclinal lies about 1½ miles to the eastward, and its eastern side, ascending to the undulating plateau of the Gauly Conda, is very distinct. The smaller folds of the strata are very distinctly seen in the deep picturesque ravine south of Pogulla (Goodsheltoora of map). The sides of the ravine form vertical cliffs, 80—100 feet high, of typical quartzites, which show the beds in very beautiful undulations, but unfortunately the ravine is so very narrow that but few of these curves can be seen at once. These undulations may be regarded as crumplings of a great flat anticlinal followed by some smaller folds and a nearly horizontal stretch of beds which disappear eastward by the sloping down of the mountain side into the Veddulcherroo valley in Nellore District.

"The only part of this section which is doubtful is the second anticlinal fold. The exact position of the beds being obscured by intense cleavage.

"The anticlinal fold west of Shingasanpully is, on the contrary, beautifully distinct, and can be followed without any trouble northward or southward. To the northward it sinks rapidly and disappears with a fine elliptical curve of rippled quartzite under the Cumbum slates close to the village of Barticoonta. Southward, the anticlinal extends beyond the Konapully pass far to the south, and becomes eventually the main ridge of the Yellacondas.

"The second anticlinal also appears to slope down to the north and disappear under the Cumbum slates of the Yamal-air valley.

"The great flat anticlinal of the Pogulla ravine extends northward for a great distance and forms a leading feature in the ridge northward of the Gauly Conda.

"Hardly anything but true quartzite of buff or drab colors is seen in this section; 'inliers' of slate are very rare and altogether unimportant. In the Unkalumma Conda some of the quartzites are grey in color, but there can be no doubt of their being a continuation of the beds in the Konapully ghat spur.

"The section now described affords a key to explain the obscure relations of the several quartzite ridges and slate valleys forming the mass of the Yellacondas further south near to Tellanela-mulla.

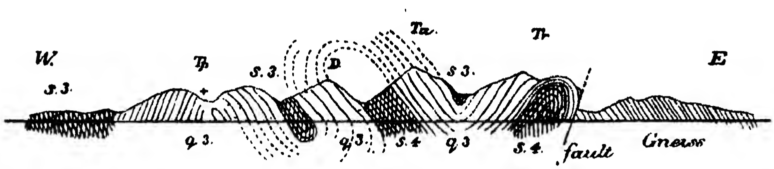


Fig. 36. Tellanela-mulla section.

Tp. Tekalepenta village on the Konapully ghat anticlinal · D. Davur Conda ridge Ta. Tellanela-mulla ridge: Tr. Toongoor ridge.

S3. Cumbum slates: Q3. Byrenconda quartzites: S4. Bolapilly slates.

"The beds of quartzite which to the north of the Konapully ghat form a rather flat anticlinal arch, are, as they are followed southward, found to assume a very much greater inclination, having been squeezed up much more violently and to a considerably greater height. As the eye can follow the outcrops of these beds for miles along the mountain-ridge, no doubt can exist of their identity. Following the line of section (Fig. 36) across the Yellacondas at Tellanela-mulla Trigonometrical Station (about one-half of a mile north-west of the village), from west to east, the southern extension of the Konapully ghat (quartzite) anticlinal is found to dip under slates on either side west and east. Those on the west are unquestionable Cumbum slates; those on the east must be the same, in the absence of faults, no signs of which were seen. These slates occur in a deep narrow valley running north and south from Konapully to Mylecherla. They are, I believe, the representatives of the Cumbum slates lost

sight of between Gollapully and Shingasanpully, because of the immense accumulation of debris there. No bedding could be made out where I crossed this valley.

"Overlying these slates comes a great thickness of quartzites, dipping eastward at a high angle and forming a great ridge corresponding with the Davur Conda ridge of the map. East of this ridge is another deep narrow valley occupied by slates, which in their turn are overlaid by another series of quartzites rising into the lofty Tellanela-mulla ridge.

"At this point the dip is easterly at a high angle, though greatly obliterated by cleavage. The quartzites continue to dip east till the head of the Toongoor valley is crossed, when they suddenly rise again with a westerly dip.

"In the centre of the valley a narrow strip of slates hides the quartzites a little. These are again underlaid by slates, appearing some distance down the flank of the mountain, and abutting against the mica-schist of the old metamorphic rocks. A little north of the line of section the overlying quartzites roll over again in a splendid curve, but are cut off by the great boundary fault. An examination of the country at the north end of the Tellanela-mulla ridge shows that the quartzite beds composing it cross over into and form the great Pogulla anticlinal.

"At the south end of the ridge the beds are seen to sweep round and form a shallow synclinal with the ridge east of the Toongoor valley. The underlying slates must, therefore, agree with those corresponding slates cropping out from under the east side of the quartzite synclinal. As the quartzites of the Davur Conda ridge appear to dip conformably under the older slates, and do overlie the younger slates in that part of the mountains, it is clear that they are in abnormal position, and in fact belong to an inverted anticlinal, as which I have represented them in the diagram. The Davur Conda ridge quartzite might, on the other hand, have been brought into its present position by faults.

"In a country where such vast foldings of strata abound, it is easy, and, in the absence of any evidence to the contrary, quite legitimate, to explain this and other difficulties by referring them to inversions of strata; more especially as several undeniable cases, though on a smaller scale, can be adduced in support. The quartzites seen in this Tellanela-mulla section are generally very typical varieties. In the western part, the predominant colors are reddish buff, whitish and bluish grey, and the two latter colors prevail most throughout the section elsewhere.

"The cleavage of the quartzite in the summit of Tellanela-mulla ridge already adverted to is quite in accordance with the prevalent cleavage of the slate beds, namely N. 5°—6°E.; dip 60°—70°E.

"The Tellanela-mulla section is obviously not an easily understood one, unless compared with the results obtained from examination of the Toongoor and Mylecherla valleys, in addition to the section across the mountains from Muddava eastward.

"By establishing the identity of the Davur Conda ridge quartzite with the Konapully ghat, the Tellanela-mulla and the Pogulla anticlinals, which belong to

the Byrenconda quartzites, the extension of the sub-group is carried as far south as Mylecherla, where the Davur Conda ridge is cut short by the great boundary fault. But there is besides little reason to doubt the still further southward extension of the Konapully ghat beds, although the quartzite beds seen southward from the mouth of the muddava valley all dip eastward.

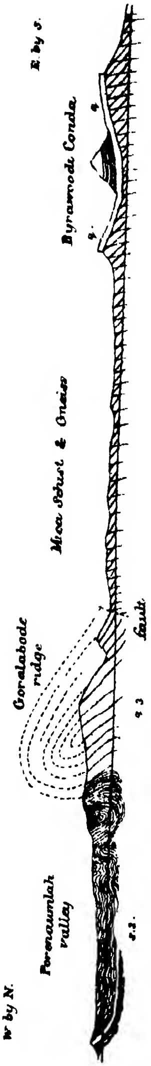


Fig. 37. Diagrammatic Section of the Porenaumla valley and Goralabode ridge.
Gb. Goralabode ridge: B. Byrawoody Conda.
S3. Cumbum slates: Q3. Byrenconda quartzites: Q. Bottom beds: G. Gneiss.

"There is no visible change of beds, and both strike and mineral characters continue alike with the more northerly part. The eye follows quartzite outcrops along the face of the mountains from the unquestionable westerly dip near the Konapully ghat to the ridge west of Mylecherla, where only easterly dips occur without any break, beyond what is caused by ravines and valleys. On the western side of the Yellacondas, where no change has taken place in the dip, the quartzites, which at Mylecherla underlie the slates of the Konapully ravine conformably, and are unquestionable extensions of the Konapully ghat anticlinal, are continued southwards past the Goralabode Trigonometrical Station and to beyond the Sheetarampoor pass. With this persistent continuation of the beds, it seems impossible that any other structure can obtain than an inverted anticlinal as shown in the annexed diagrammatic section* (fig. 37).

"Owing to the extent of denudation the crown of the arch has been removed entirely, which renders the section necessarily very obscure, by doubling the apparent thickness of the formation. The greatest amount of overthrow or inversion of the anticlinal appears to occur a little south of the Goralabode peak, and it attains probably an angle of 45° east on the west side of the mountains; further south, the beds seem to lean over to a considerably lesser extent. To the north, at the mouth of the Muddava ravine, the dip is 60°

* It is along this axis that I am inclined to suppose a system of north-south faults in preference to an inversion. (See Pt. IV., Chap. I).—W. K.

east; while a few miles further north, the beds show a dip of 80° west. Near the north end of Konapully ghat anticlinal, the dip of the west side of the arch is 75° west, and diminishes greatly to the elliptical extremity of the anticlinal.

"The inversion of the Davur Conda ridge is not so great as that of Goralabode; the former not exceeding a dip of 70° or 75° east.

"The section shows the configuration and structure of the Porenaumla valley, a little north of the great tank; of the Yellaconda ridge, between the Goralabode and the Sheetarampoor pass; and of the outlying quartzite mountain Byrawoody Conda.

"In lithological character there is no difference between the quartzite beds extending from the Myleeherla peak southwards to the Sheetarampoor ghat. Both at the pass across the Myleeherla peak and the Sheetarampoor ghat one crosses over a great series of quartzites, chiefly of the pure hard semi-vitreous variety. A few large quartz veins, with north-south course, occur traversing the quartzites.* The prevalent colors of the quartzites are greyish white, bluish grey and drab; rippled surfaces are less frequently seen hereabouts than further north.

"The northern part of the Yellacondas shows a continuation of the same beds as form the Gauly Conda and Pogulla plateau under similar circumstances of position and configuration, the quartzite beds being generally of pure typical semi-vitreous varieties. About three miles to the north of Gauly Conda, the anticlinal structure of the mountain-ridge is very obvious, although complicated by several minor undulations of the beds. The westerly dip of the beds, which at Pogulla is easy and gradual, has become very high at Chennoopully; and still further north at the Nerdy Cunnama and Junna Cunnama appears to have been inverted, the dip of the beds having changed to the east. Both the latter sections are obscure and not to be reconciled with the Chennoopully section but by assuming an inversion; no faults being traceable by which such an immense succession of quartzite beds, with easterly dips, could be otherwise explained.

"In the section near Chennoopully a splendid traverse of the Byreneonda series is shown in two deep ravines on the west flanks of the Yellaconda ridge. The head of either ravine is formed by splendid cliffs several hundred feet high, of drab and whitish, waxy quartzite, stained in most parts by decomposition of ferruginous particles of a bright red colour. The faces of the cliffs are formed by vertical north-east-south-west joints, the axis of the anticlinal striking north by east. The section of the beds by the north-east joints forming the faces of the cliffs lies just eastward of the first curve of the beds west of the main anticlinal axis, so that the curve is fairly seen from points occupying the same level; from below, the section is a very puzzling one.

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* Indications of broken strata.—W. K.

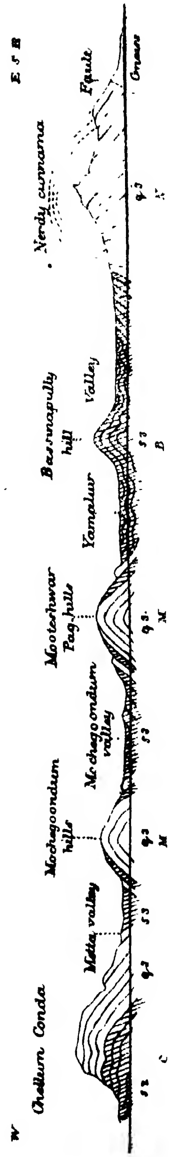


Fig. 38. Chellumconda and Nerdy Cunnama Section.
C. Chellumconda: M. Moaksheegoondum ridge: M. Mooteshwar ridge.
B. Bassinapully ridge: N. Nerdy Cunnama.
S3. Cumbum slates: Q3. Byrenconda quartzites: S2. Bolapilly slates.

"The structure of the Yellacondas, from a little south of the Nerdy Cunnama (see fig.) to the acute bend opposite Cumbum, is far from clear; the beds seem persistent all the way, yet the unquestionably westerly dip of 60°—75° of the beds at Chennoopully, and for several miles north, has given way to an easterly dip of 75° about half way up the west slope of Nerdy Cunnama, and of 45° near the top of the ghat where the axis of the inverted anticlinal has been crossed in proceeding eastward. The greatest amount of inversion would appear to exist about half way between the Nerdy and Junna Cunnamas. On both sides of the anticlinal are numerous deep ravines, but none of those I examined showed the apex of curved beds.

"The section across the Junna Cunnama shows the same beds of quartzite as at the Nerdy Cunnama; but the section is far less distinct. The bedding of the quartzites on the top of the ridge is most obscure, partly because of the homogeneity of the rock and partly owing to the prevalence of cleavage planes; to these causes are superadded a third, namely, excessive weathering which has covered great part of the ridge with a coat of broken fragments. Near the west end of the small level which occurs at top of the ghat I noticed what might possibly be part of the arch of one of the beds, but the exposed surface only measured a couple of square yards in area and might possibly belong to a large fallen mass and therefore not be *in situ*.

"Still further north, the anticlinal returns to its normal position, and after the sudden eastward bend it is much flattened out; and by the time the Peddakoo hill is

reached the curved character is almost obliterated by the denudation of the south side of the anticlinal having been greater than of the north (Fig. 39).

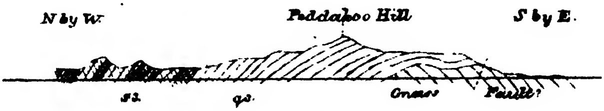


Fig. 39. Section at Peddakoo hill.

"A change in the lithological character of the beds has been gradually taking place from the northward of the Junna Cunnama, many of the quartzite beds having assumed a markedly micaceous character which seems to be increasingly developed eastward of the Vamalapaud pass. Some of the beds are so micaceous as almost to pass into a mica schist. Some of these are to be seen near the Nellore end of the pass about half a mile north-east from the foot. Like the typical semi-vitreous varieties these micaceous beds are almost invariably of pale color; either pale pink, white, grey, bluish or greenish.

"The bottom bed of the KADAPAH ROCKS in this part is of a mixed character, partly semi-vitreous and pure; partly also rather micaceous;* it is well exposed on the flanks and summit of the Lingumcoontla spur of the Peddakoo hill. The unconformity of this quartzite to the underlying gneiss and mica-schist is very marked, although in some places an apparent conformity has been caused by the extensive and complicated crumpling of the quartzite bed."

Byrenconda outcrop towards Muntaral Cunnama.

The Cumbum tank-ridge of ripple-marked quartzites, both flaggy and thick beds, is traceable continuously northwards to Tirmaldaverconda beyond the Tiggle-air, when the inclination of the beds becomes suddenly lower, and there is a twist round of the strata to the westward. Tirmaldaverconda is found to be capped by these beds, and west of that all recognition of a separate band of quartzites is lost in the superficial

* This bed, if really belonging to the Byrenconda group, would by its position indicate an overlapping of the lower beds by that group. Such an overlap may really exist, but it is also quite possible that the bed in question may represent the true base of the KADAPAH rocks, in which case the equivalent of the four remaining sub-groups would have to be fixed among the overlying beds near the base of the Peddakoo section. In the latter case a great lateral change of mineral characters and also a great thinning out of all the beds must have taken place, as compared with their vertical extent and lithological peculiarities in the typical region north-east of the Byrenconda.—R. B. F.

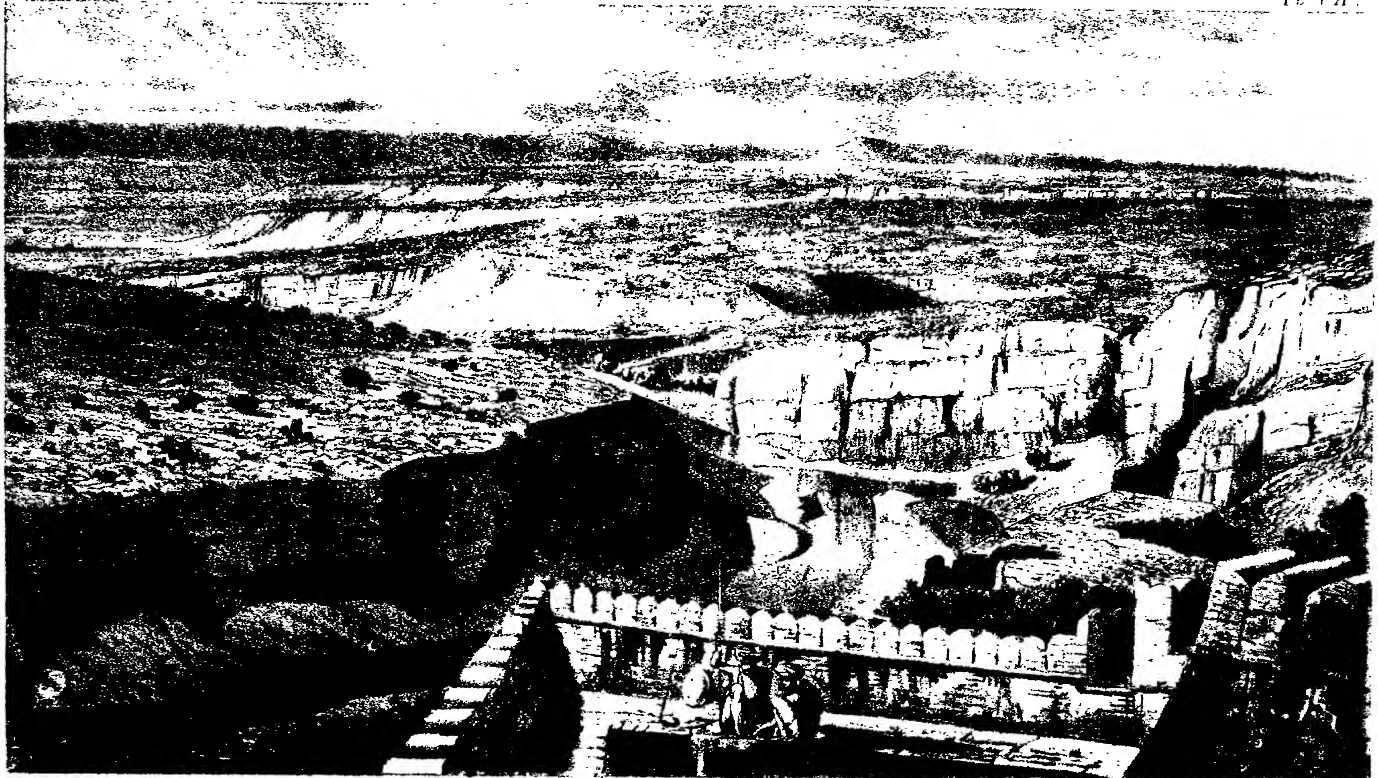
covering of the flat country. The sub-group may very possibly be represented in the Raigoomanpully ridge further west; but there is no recognizing it there more particularly than in any other of the numerous outcrops of quartzites in this part of the field. At all events, whether the Byrencondas are represented by the quartzites of Raigoomanpully or not, they most probably have died out to the westward, for this is the case with all the other bands of quartzites which run into the valley in this direction, except those of the great Eeshwarnacoopum nucleus.

Apparent break in the north-easterly extension of strata.

In this north-east part of the field, *viz.*, in the country north of Dorenall, Doopad, &c., which is mainly a slate region, the different bands of quartzites in the slates are most confusing in their outcrop, for they have generally, supposing they are continuous with those of the Cumbum valley, become reversed in their dip and twisted in their course. It seems as though Mr. Foote's abrupt west-north-west east-south-east Donaconda fault, on the eastern edge of the area, were continued in the same direction past Doopad, and that this, in conjunction with other lines of dislocation running along the Dorenall valley into the lofty and quartzite-scarped Innaparatyconda, might account in part for the evident breaks in the bands of strata in this part of the country.

Style of Gundycotta quartzites.

In the Gundycotta or Jummulmudgoo range of hills, the slaty shales, &c., of the Penn-air are overlaid unconformably by a series of massive quartzites. The uppermost beds here of the *Chey-airs* are red, earthy, and occasionally sandy slaty shales with intercalated thin bands of quartzites; and these in following the course of the river through the Gundycotta gorge appear to be perfectly conformable with the great thickness of quartzites with a few thin bands of sandy shales which is seen in the great cliffs of the eastern part of the gorge. The dip is only about 5° or occasionally 10° to the north-eastward. However, when the south-west scarp of this range



W. King delt. J Schaumburg Lith

GUNDYCOTTA GORGE.
on the Pennair

of hills is followed out, it is gradually seen that the higher quartzites are by degrees overlapping different beds—ferruginous coarse sandstones, flags and shales, more particularly at the Cuddapah end of the range, and thus the unconformity becomes evident.

The series consists of little else but massive beds of pale-colored quartzite sandstones, sometimes ferruginous, with a few bands of red and purple sandy shales, the latter of which are seen on the lower north-east slopes. There are thus displayed in the passage of the Penn-air river some 600 feet of strata. The cliffs are from 2 to 300 feet in height, showing the great beds dipping down towards, and finally underneath, the Jummulmudgoo country.

The accompanying sketch (Pl. vii) of the Gundycotta gorge, taken from the fortress overhanging the cliffs, is illustrative of some of the features of these strata.

In the low range of hills further north, these quartzites again rise up from under the limestones; and the outcrop of red and purple sandy shales which is seen at the foot of their steeper northern slopes are apparently representative of the shales in the Baukrapett valleys north of the Gundycotta fort. Beds of the same kind are seen further west at Pellnycota.*

Inliers.

The low hills in the very middle of the Khoond-air valley—Poospageery and the smaller one of Goteloor—are of quartzites, which would seem to be the same as those on either side of the valley.

The Cumbum Slates.

Byrenecondas overlaid by slates.

The Byrenconda quartzites of the Pollconda ridges, the Nullamullays, and the Cumbum tank-ridge, &c., are overlaid by a great series of slates, which have no representatives in the western part of the field. They are continuous from the

* South of Oopalpád plateau.

Chittavail valley south of the Chey-air right up past Cumbum into the Doopad and Vinuconda country, which is girt in by the north-eastern spur of the Nullamullays and the northern outliers of the eastern ghats, striking up to the Kistnah river.

Extent of slate series.

This sub-group of slates is the most extensively developed series in the KADAPAH ROCKS, occurring, as it does, all along the eastern side of the field—lying alongside the gneiss rocks for the northern half, and inside of the Yellacondas for the southern half of the length, except at the southern end of this mountain-ridge, when the slates themselves partly form the ridges and are finally again brought up against the gneiss by a boundary, which is evidently a faulted one. Westward of this they show in the Muntaral Cunnama,* over a large extent of the Nullamullays, and again over nearly half the KADAPAH basin of the Chey-air.

Strata vary much.

Over this stretch of country the rocks vary considerably in their character, a circumstance which is mainly due, however, to the fact of successive strata being every now and then brought to the surface by undulation, of which there is a great deal over the whole field. This is intensified from Porcnaumla northwards, or rather appears to be so, for the crests of undulation have not come sufficiently near the surface to the south, there being only one clear band of quartzite outcrop† along the rest of the valley down to the Penn-air, while there are numerous outcrops northwards.

Folded strata.

Far to the north of Cumbum, in the Waumyconda range (the north-eastern spur of the Nullamullays), there are cases of reduplication and inversion of the quartzite strata among and above these slates. Mr. Foote's descriptions (already

* The run of east and west valleys crossing the northern part of the Nullamullays along which the road leads from Kurnool to Guntoor.

† These quartzite bands are the main, if not the only, guides to any clear and extensive examples of undulation.

given) show how the quartzites underlying the same series in the northern part of the Yellacondas are likewise much folded.

Intercalated bands of quartzite.

It is a feature in the Cumbums that bands of quartzites of greater or less thickness are more frequently intercalated than in any other of the slate groups. These are very often confusing, on account of their general resemblance to one another and to other quartzite runs; it being difficult, if not impossible, to say whether they really belong to the slates or to a superincumbent series.

Thickness of slates.

The wide superficial display and the average dip of these slates suggests an enormous thickness; but this is to some extent deceptive, owing to the undulatory lie over the wider areas. Taking the section (No. 1, Plate IX,) just south of Porenaumla, there must be a thickness of over 3,000 feet; and below that part of the Byrenconda which is capped by Irlaconda quartzites, there are again 3,000 feet. These are, perhaps, about the safest thicknesses taken in the eastern field, as representing them at their deepest, for they thin out a good deal to the north and north-east.

Character of slates.

The slates are of all varieties from fine silvery talcose beds, through coarse grey, purple, and blue slates, to grey and reddish-brown earthy clay-slates. They are occasionally foliated and schistose, often not to be distinguished from the schistose crystallines alongside of them. It is quite impossible to say in numerous localities how these different varieties occur with regard to each other, except when there are good continuous outcrops; while the cleavage is so strong that quite a magnified idea of the thickness of the beds may be produced on the mind of the observer.

Along the base of the western slope of the Yellacondas the strata are dark-green talcose and chloritic slates, almost schistose, weathering generally of a dark rusty-brown color. Below these, as in the Budvail and Porenaumla belt, they are pale-brown and reddish, streaked,

earthy clay-slates with slaty flags, and then there is an intercalated band of quartzites. They are at the same time along here less cleaved than in other parts, and more distinct in their stratification. Still lower, or in the Kullsapad belt of the valley and its extension southwards, there is a broad band of pale green and silvery-grey fine talcose slates, very much cleaved, and zigzagged* in the lamination, as well as sharply folded. With these are associated dark green and blue earthy varieties, until on the eastern flanks of the Nullamullays dark-colored and coarse slates in massive beds with quartzite flags are again reached.

Intercalation of limestones.

In certain localities a good thickness of limestone beds are associated with the Cumbums, as in the Kullsapad valley for long distances: and again† in the neighbourhood of Cumbum, and so by broken patches right up north-east into the Markapoor and Vinuconda taluqs.

From the Penn-air southwards, beds of limestone are very strong, particularly about Ontimitta; and the same set of beds crops out along the western flanks of the Nullamullays up to and beyond Nundiallumpett. In the Nullamullays to the east of this last village, there is a further display of more silicious limestones, which may, however, belong to the same set as that striking past Nundiallumpett. These are not seen to any extent in the Lunkamulla range to the south, as they have very possibly been denuded, the Cumbums having originally formed the higher part of this mountain mass.

From Kullsapad northwards the limestone outcrops are not again seen until some twelve miles south-south-east of Cumbum, close up alongside the Yellaconda range, when they strike away north-eastwards, and

* This zigzag lamination is very marked all down the Porenaumla side of the ridge to the Penn-air.

† This break between the Kullsapad limestones and those of Cumbum is interesting in connexion with the supposed series of faults striking along part of the watershed between the Suggle-air and the Gundlacumma.

eventually show apparently in two or more bands of slates between others of quartzite, which are brought to light again further to the westward in broken patches of outcrop in the neighbourhood of Mootakoola and thence north-east towards Melluvagu. Here, at Mootakoola, they show very strongly in the axis of an anticlinal; and the characters there displayed are tolerably constant in other limestone outcrops of this part of the country. They are generally compact, fine-grained, semi-crystalline limestones, and are very often micaceous, or talcose, sometimes extremely so with fine laminæ of silvery pale green talc. They are of a slate-grey color generally, but tinged more or less of a red purple. Occasionally, and when very talcose, they are of a semi-translucent pale green color, as at Mootakoola. In one locality* they are pure white, and more crystalline than is ordinarily the case; as in a series of strata cropping up along the middle of the Waumyconda range of hills north-west of Murryvamla.

Often very like limestones of the KARNÚLS.

At times it is difficult to distinguish beds of this set of limestones from some strata of the KARNÚLS, as, for instance, at Kakeralla on the Palnad side of the Waumyconda, north of Murryvamla. These are the same as the much more crystalline and white vertical limestones in the mountains a few miles to the south-west; but further north in the Palnad, there are limestones of the KARNÚL rocks which are hardly to be distinguished from the Kakeralla beds; only, that the latter are under the quartzites of this mountain-ridge, which are themselves subjacent to and much older than the limestones in the Palnad.

The different outcrops seen in the country south of the Waumyconda range are very possibly of the same series; or all belong to one period of deposition of intermittent calcareous strata, though they are

* It is here that the most evident cases of reduplication and inversion of the strata may be seen. The sharp doubling of the beds here has been too much for their flexibility; and the very altered look of the limestones and quartzites is probably due to a slip of the strata over each other in a west-south-west fault.

found so very clearly in some localities as one set of beds without intercalated slates, while in others they show as numerous bands among slates. Or there may be two sets of beds, one low down in the Cumbums and the other near the top of the series. In the Kullsapad belt, the beds are generally of grey colors, fine-grained, semi-crystalline, and waxy-looking.

Limestones of the Penn-air.

The limestones of the Penn-air are generally of a more compact and silicious character than those in the Cumbum country, though they seem to belong to the same series.* There are likewise two bands of limestone here, which come out more distinctly in the Lunkamulla range north of the Penn-air, on the western flanks of this mountain mass, the lowest running along the base or near the base, while the second crops out about halfway up the slope.

In Baukrapett hill.

There is a fine show of the lower band of limestones in the Baukrapettconda to the east of Cuddapah town; but their lie, and that of the quartzites and slates both above and below them, is exceedingly obscure, owing to the crushed up arrangement of the strata between Baukrapett Peak and Pollconda on the western side of the narrow valley leading south-west from Cuddapah.

* For the present, this doubtful area is considered as belonging to the Cumbums; though I feel in my own mind that it is a mistaken view of the relations of these strata. I am strongly inclined to look on these beds of the Baukrapett hill and even of the whole of the Lunkamullas as not of the Cumbums at all, but as Poolumpetts, and that they are let in here by a series of faults, of which the Kaukulconda fault down on the Penn-air, the evident dislocation in the Baukrapett pass east-south-east of Cuddapah, and the fault along the Nundiallumpett beds of the Nullamullays are parts. Certainly the Baukrapett limestones are intensely like the Poolumpett beds; while the Lunkamulla strata are not at all like the strata north of the line of faults striking east and west through Nundiallumpett. At the same time I do not consider the strata of Ontimitta and to the south of that village as anything else but Cumbums.

I confess, however, that I am at a loss to show this at all clearly on the map; and in fact it could not be done except after a thorough and close re-examination of the Lunkamulla region.—W. K.

The Baukrapett variety is a hard black, or very dark silicious limestone weathering grey, in which at times it is difficult, if not impossible, to recognise any stratified structure. At a distance the rock is in appearance more like an igneous outburst than anything else, black, hard, and rugged in the sharpest degree. In the Penn-air or Ontimitta area, the limestones are very tantalizing in the detached way in which they show at the surface, being sometimes nearly horizontal and lying easily over a large space of ground, and then suddenly turning up at all sorts of angles, or even disappearing altogether. There is a fine show of easily lying beds in the flat between Ontimitta and Baukrapett; while this is cut off quite suddenly on its eastern side by a very sharp turn up of the beds, the quartzite flags and hard slates beneath them filling up that side of the country for some distance. Then they are not seen except by the faintest traces to the south, or south-east.

Signs of faulting.

These peculiarities are doubtless largely due to denudation over the sharply undulated western beds and to the thinning out of the limestones; but there must have been some faulting. As a rule, these strata are most uncertain in their thickness and lateral extension: witness their thickness of 200 feet at least under Baukrapett, and their almost total disappearance, or thinning out to a 30-feet group of slates and thin limestones, to the southward along the edge of the Ontimitta trough.

After crossing the Penn-air to the western flanks of the Nullamullays, the strata are much crushed up and possibly faulted. The quartzites of the ridges between Cuddapah and Baukrapett peak are often quite vertical, exceedingly fractured and impregnated with quartz; at the crossing of the Penn-air, they are in a series of three or more north and south folds. These are apparently under the limestones which seem originally to have lain with these undulations, or were crushed out of them. Still the limestones are continuous in their outcrop, though they separate into two or more bands with intermediate slates

that run under and behind and above the quartzites of Goomconda, and so along the bases of the Lunkamulla towards Nundiallumpett. There is a break in their continuity when they reach the southern end of the tank of the last village, but the same beds with quartzites above are again found a mile to the westward when they are again traceable into the ridge west of Wonypenta.

Obscurity at Nundiallumpett.

Unfortunately in the Nundiallumpett, or Parnapawd, outcrops there is a very great deal of obscurity; as, besides the fact that the ground is much obscured by the alluvial deposits of the Annaloor plain, the newer KARNÚL limestones are in juxtaposition with these KADAPAH limestones; and they also have been affected to some extent by some of the forces which produced the rapid folding of the older strata, or their possible fracture along what must have been a complicated northerly system of dislocations.

Hotcomudgoo faults.

That there has been some east and west displacement of the strata in the Lunkamulla mountain-mass and the lower part of the Nullamullays to the north of it is evidenced not only by this break at the south end of Nundiallumpett tank, but by another line of distinct displacement of outcropping bands further to the east in the Hotcomudgoo valley. Here the northern bands of silicious limestone have been cut off completely, as they do not show to the south,. while there are no traces of extensions of the

Downthrow to the south.

Jundermorum bands in the Lunkamulla country immediately south. There has clearly here been an upthrow* of the beds to the north; and the subsequent denudation has thus exposed beds of limestone which are buried deep under the basement of the Lunkamullas. Hence northwards the limestone bands of the Cumbum slates, as they occur in the Nullamullays, die out

* That is, supposing that the Lunkamulla beds are Cumbums.

or disappear. Traces of lead are still, however, apparent, and the ore was worked largely in the Cumbum slates north of the Nundy Cunnama pass.

Limestones metalliferous.

It is in these silicious limestones of the Nundiallumpett part of the Nullamullays that the old lead-mining operations of the Moguls were carried on; and in which there are still good traces of that mineral. Report says likewise that lead has been found in the western slope of the Lunkamullas, and down in the bed of the Penn-air south of Goomconda; but no traces of such were observed by the Survey.

Regions of quartz impregnations.

In certain regions these slates are extensively impregnated with white quartz: and this is most conspicuously displayed along the middle third of their area, that is, between the Penn-air river and Giddaloor, about twelve miles south-south-west of Cumbum. Within these limits the quartz-runs come to the surface along the middle of the depression between the Nullamullays and the Yellaconda range, and to some extent along the talcose and chloritic slate outcrop at the western base of the latter mountains between Budvail and Porenaumla. There is an enormous quantity of this mineral distributed among the slates in the middle band; so much so that the country is marked for several miles from north to south with white ridges and reefs and scattered debris of the same.

Again, in the northern part of the Cumbum country the slates are occasionally largely charged with quartz, more particularly around Mootakoola (20 miles north-north-east of Doopad) and in the Gungwaram hill to the west and south-west of that village. For the most part, the quartz is interlaminated with the slates, occurring only partly in the interspaces of cleavage: and it is most thickly deposited in or near the curves of undulation.

No minerals of value in them.

These quartz-runs and strings are extremely unproductive, there being no trace of any mineral ores except small strings of hard grey specular iron ore. These do not occur in sufficient quantity anywhere in the field to have ever been worked: the iron ordinarily obtained in these districts being from one or other of the quartzite groups.

As a conclusion to this description of the Cumbum slates, the following notes of Mr. Foote are appended, as he more especially surveyed the typical Cumbum area:—

Mr. Foote's notes on the Cumbums.

"From the very great prevalence and the thickness of the surface soil and other recent formations, and the comparative rarity in the valleys and plains of any but well-sections, it would be impossible to form any clear and detailed idea of the true sequence of the several minor formations of slate and quartzite with a few small limestone bands which make up the Cumbum sub-group without having surveyed the country in extreme detail and laid it down on a large scale. Many of the beds are doubtless frequently reproduced on the surface by numerous crumplings, and as in many cases the mineral constitution of a bed changes within a few score yards, it is quite unsafe, in the absence of the guidance of fossil remains, to attempt any further sub-division of the group. A few of the principal features, which were of sufficient importance and distinctness to be mapped, have been laid down in the map. The chief of these is the occurrence of a band of quartzite and silicious slates of no very great thickness which forms a horse-shoe bend right across the centre of the Cumbum plain, beginning close to the north end of the town and trending north and east and then turning suddenly south and crossing the Gundlacumma river just a little above its bend to the north at a distance of five miles from Cumbum. South of the river the quartzite beds stretch away south-south-east in a nearly straight line as a generally low ridge, or rather succession of ridges, which runs far up the Yamal-air valley and divides it into two parts.

"This quartzite forms the crest of two large hills in its course; the one the elephant hill (the Yanegayconda Trigonometrical Station of the map) two miles north-east of Cumbum, and the Mullapoor hill at the mouth of the Yamal-air valley. South of the town the quartzite has disappeared and apparently passed into a silicious slate, for no quartzite outcrop is seen in the bay formed by the Cumbum slates south-west of the town.

"In many parts of the ridge, the band of quartzite is fairly replaced by silicious slate; and where this is the case, it is not always possible to state which part is the exact representative of the thin quartzite band of a distant part of the ridge. In

general the band is characterized by clearness of stratification as shown by its numerous ripple-marked surfaces. Some beautifully perfect examples of the latter are to be seen about half a mile north-east of the village of Lunjakola. The quartzite there exposed shows numerous rippled surfaces; indeed, they recur every three or four inches throughout the thickness of the band. One very rocky part of the ridge to the north-east of Lunjakola shows a very pretty example of inversion of the quartzite bed, here beautifully rippled. The inverted part is only about 50 yards in length.

"On the south side of the Gundlacumma river the ridge south-west of Molapully* is the continuation, above alluded to, of this quartzite band and its associates, which may be readily followed up by the eye even from a distance into the Mullapoor hill. On the east side of this hill especially are many fine examples of ripple-mark in slaty quartzite. Some very interesting examples of the distortion of the ripple-marks by cleavage and by crumpling of the beds are to be seen here. In some of the small sharp folds of the beds the small ripplings have been so squeezed up as to resemble roughly the flutings of a Doric column. In other very acute foldings the rippling has been so squeezed together as to form masses bearing no inconsiderable resemblance to casts of lepidodendron stems with immensely large leaf-scars.

"Southward of the Mullapoor hill this quartzite bed cannot be traced any longer with certainty; it has been denuded down to the general level of the valley, but there is some reason to think it may be represented by one of the quartzite ridges appearing near Junnapalcherroo. About three miles south of the Mullapoor hill lies another of considerable size and elevation which is remarkable for the fine section of the Cumbum slate series shown on its southern face. The structure of this hill appears to be very complicated; and its connexion with the rippled quartzite beds of the Mullapoor-Yanegay ridge, though probable, is far from obvious. The probable positions occupied by the beds occurring in the centre of the Yamal-air valley seem to indicate a synclinal.

"The general relation of the Cumbum slates in this Yamal-air valley to the Byrenconda quartzites will be better understood if reference is made to the section given, Fig. 38, page 224, which illustrates the general structure of the country from the Chellumconda south-west-by-south of Cumbum to the Yellaconda ridge where crossed by the Nerdy Cunnama.

"Southward from Bassinapully hill there are two quartzite ridges lying to the east of the Yamal-air streams; but I could not satisfy myself as to their being positively representative of the band in Yanegayconda ridge, the intervening part of the valley being thickly covered with soil and quartzite-shingle deposits, and in many parts additionally obscured by thick bushy jungle. My impression is, these two ridges are

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* The nameless village (of the map) at the bend of the river.

the two outcrops of a synclinal fold which meet together at a very acute angle at a point somewhat to the east or south-east of Shingarypully; but that part of the valley is extremely obscured by the quartzite-shingle and extensive jungle.

"Still further south, between the ruined and abandoned village of Gollapully and Shingasanpully, the Cumbum slates are completely obscured by debris, which is of great thickness. In the valley running up into the hills south-south-west from Konapully* slates are seen at several points in such positions that it is hard to understand to what group they belong, unless it be the Cumbum group. My examination of the group of mountain-ridges south of Konapully led me to believe that the slates of this valley are a continuation of the slate beds which overlie the quartzite forming the ridge west of Konapully; and these quartzites I consider as being unquestionably the same as the beds forming the Unkalummaconda, which rise from below the typical Cumbum slates all along the west side of the Yamal-air valley.

"Whether the Cumbum slates are continued southward down the Hanoomypully valley to join the great area of Cumbum slates in the Porenaumla valley is somewhat uncertain; the small valley south of Hanoomypully being full of quartzite debris and shingle which completely obscure the underlying rock. It is very likely that at the highest part of the valley where the watershed is situated, the slates might be found to have been entirely denuded away; but at both ends, at Hanoomypully and a mile to the north-east of Chintalpully, the Cumbum slates are exposed in well-sections.

"Both above and below the Yanegayconda ridge quartzite-bed are several beds of crystalline limestone,† almost the only ones met with in this part of Kurnool district. They are of no great importance, being generally small or so much mixed up with slate laminæ as to be of no value as building stones, or for ornamental purposes. These beds occur chiefly in the Yamal-air valley, south of the village of Mullapoor. South of that place are several beds of bluish or whitish-grey, or pale dirty pink crystalline limestone, intermixed with pale grey slates, and overlain by pale bluish, greenish, and grey talcose slates. The limestone beds, which are upturned at an angle of 70°-75° east, form a synclinal fold about half a mile across, the intermediate space being occupied by the slates just mentioned. The dip on the eastern side of the trough is 50°-60° west.

"The synclinal fold is most probably a complete one as shown in the section above quoted, and not a simple fold with a constant dip of 75°, which would demand for the Cumbum slate group a vastly greater thickness than there is any reason to

* This valley is only indicated on the map at its north and south extremities, but it forms a great north and south furrow in the mountains running from Konapully down to Mylecherla.

† These are what I have called sub-crystalline limestone bands in the Porenaumla valley; there they are not properly crystalline limestone; and probably Mr. Foote's bands are hardly so crystalline as his term would indicate.—W. K.

assign to it. The limestone beds of the west side of the synclinal were best seen about half way between Mullapoor and Junnapalcherroo; they are about 50 yards thick across the strike, including the small intercalated slate beds; but to the north near Mullapoor they have disappeared and been replaced by slates, excepting a few little beds 2 and 3 inches thick which are exposed in well-sections south of the village. The limestone beds of the east side of the synclinal also disappear and are probably replaced by slates. I could not trace any limestone at either end of the hill lying east of Mullapoor village, which hill occupies the position in which the continuation of the limestone beds should occur.

"The beds just described overlie the Yanegayconda ridge quartzite bed. Underlying this quartzite bed (apparently at least) is a series of small limestone outcrops (very likely the different re-appearances on the surface of a single bed) which extends at intervals from the south-east end of the Mullapoor hill past Junnapalcherroo, almost as far south as Bassinapully village. This limestone is of grey or dirty-white color and not very pure, being mixed with small lenticular patches of slate like flattened clay galls. This bed is so slightly exposed (only a few inches above the soil) that I could not satisfy myself as to its positive relation to the great anticlinal curve of the Bassinapully hill.

"Another small bed of crystalline limestone occurring about half a mile north of the village of Vungapaud, and at the west side of the Mullapoor hill, though but of small size, is noteworthy; it would furnish a handsome marble, being of small grain and of a pretty pink and grey color with green (chloritic) laminæ. This bed unquestionably underlies the Yanegayconda quartzite bed. At the foot of the west end of the Yanegayconda itself is a small indication of grey crystalline limestone occupying a very similar position with the last named bed relatively to the quartzite bed.

"The beds forming the broad flat plain traversed by the Gundlacumma to the north of the Yanegayconda ridge consist mainly of pale bluish-green or pale-grey slightly talcose slates with much silky lustre. These slates are generally well bedded. The lower slate beds, however, *viz.*, those more immediately overlying the Yanegayconda quartzite bed, are of dark brownish or greenish-grey, passing at some places into a silicious schist. There are probably numerous small beds and laminæ of limestone scattered about among the slates of this valley, their presence being indicated by large quantities of kunkur in all shapes, massive, stalactitic, and pisolitic.

"The plain of the Gundlacumma valley is in this north-east corner of the south-west quarter-sheet (76) broken only by a few small low hills lying between Noydopulla and Shetanagrum Agrarum. Three of these are very interesting because of their shape and structure; for they form very perfect elliptical domes of rippled quartzite. These quartzite beds occupy apparently the same position as the Yanegayconda quartzite bed; but they differ rather in their petrological character, which is that of

pure compact typical quartzite, unlike the frequently slaty or talcose quartzite of the ridge. The overlying slates are coarse silicious and of dark green-grey color.

"The largest of these three hills which rises close to the village of Noydopulla is a pretty regular ellipse, about 1¼ miles in length by half a mile in width, and has an elevation at the highest part of the ridge of 100—150 feet above the valley. The hill being perfectly bare, the lie of the beds is conspicuously visible; and a finer show of rippling occurs here than in any other place I am acquainted with. Where the surface of the hill had been broken into by small quarries, I noticed many places in which five or six or more rippled surfaces were exposed one under the other in as many beds of the quartzite. Each bed differed from the others in the direction and size of the ripple shown; the strike of the cleavage-planes of the slates around and overlying the quartzite at the north end is north-by-east. In the small northern hill, though only 300 or 400 yards to the north, the strike of the cleavage-planes has changed to north-east, dip south-east. The absence of cleavage in the quartzite, in addition to the difference of color (pale drab) from the dark-slate, renders the line of junction extremely striking; while the presence of a crest-like patch of the slate rising in jagged edges from the steep dome of quartzite arrests the eye even at a great distance (from the northward) by its resemblance to a classical helmet. The third elliptical dome is presented by a tiny hill or hillock on the north-west of the last described. The ellipse is between 200 and 300 yards long and 30 to 40 feet high, and the curving of the quartzite beds beautifully shown. Northward of these quartzite hills slate prevails very largely and seems to occupy great part of the Markapoor taluq."

CHAPTER 5.—BEDS OVERLYING CUMBUM SLATES.

Cumbums succeeded by thick bands of quartzite.

The Cumbum slates are again overlaid in several parts of the field by well-marked and thick sets of quartzites, which are much more distinctive than those other bands which eventually in their course of outcrop thin out and often disappear altogether.

Southern part of Yellacondas.

In that part of the Yellaconda range extending southwards from a point opposite Kullsapad, the Cumbum slates of the Budvail side are clearly overlaid by a great series of quartzites which go to form the main mass of these eastern ghats.

In Byrenconda.

Again, in the Byrenconda range the Cumbum series is subjacent to one of quartzites, which goes to make up the higher masses of that part of the Nullamullays, as in the Nemillygoondum region and again on the Nundycunnama, and further south still in the mountains above Howhoblum Pagoda.

In the Kistnah Nullamullays.

In the northern part of the field of these slates, they roll down under the quartzites of Waumyconda, the eastern part of the Kistnah hills, and possibly underneath the strata of Irlaconda. This part of the country is, however, full of obscurity, for the intercalated bands of quartzite are numerous and not traceable continuously for any distance; and it is thus difficult to say whether all the bands in the Waumyconda, or Innaparatyconda, &c., belong to the Cumbums or not. From what has been seen of the rocks, it would seem as if the higher quartzites of Waumyconda were representative of those of the Yellaconda, and the lower bands were the intermediates of the Budvail valleys and of the higher parts of the Lunkamulla. Under this view, the uppermost quartzites of the Kistnah Nullamullays would answer to the Yellacondas, while the lower series of Irlaconda might be representative of the Kullsapad quartzites; the Innaparatyconda quartzites being the same as these last, and let into their peculiar position in the range by faulting.

Indications of unconformity in the Kistnah region.

There is no indication of unconformity between the Yellaconda beds and the Budvail slates; nor is there any between the uppermost Kistnah beds and the slates beneath. But there are traces of such a break in the Waumyconda range of hills; the quartzites and intermediate red sandy slates of the higher parts seem to be a thinning out of the Kistnah beds, and thus the bottom of these, or the quartzites immediately north of Innaparatyconda ridge, are unconformable on the Cumbums of the Dorenall or Muntaral pass.

Southern Yellaconda beds.

The Yellaconda mountain-ridge is for the length indicated, *viz.*, from about the parallel of Porenaumla down to the Rawpoor-ghat, mainly made up of these quartzites. They are generally grey, white, or buff sands and grits in thick beds, very compact, vitreous, and in some bands, particularly the lower, rather waxy looking. Intercalated with them are thinner beds and flags, and there are occasional thin bands of slates and slaty flags. No conglomerates were observed of any importance. The beds are dipping to the eastward, regularly all down the range, at various angles, though the average is about 30°; and they are overlying a decided band of brown and green talcose slates. There is some undulation in the beds more particularly on the eastern slopes of the ridge. Towards the Penn-air river on the north side, the highest beds exposed in the lofty mass of Pedda Mallam Conda are nearly horizontal, thus giving some fine scarps on the eastern face of the mountains.

Thickness.

North of the Penn-air, the thickness of the quartzites now left is well displayed, and there must be at least 800 or 900 feet of them. South of the river, they are at a much lower level in the hills; and there is no distinct evidence of subjacent slates on the western slopes.

Eastern edge concealed by talus.

On the eastern side of the range the base of the slopes is an exceedingly wide deposit of broken and somewhat rounded debris of quartzite; the greatest width of this talus being 1¾ miles, without any rock being seen *in situ*. Consequently it is, on the whole, almost impossible to conjecture what kind of junction there may be hidden beneath between these quartzites and the gneiss which lies outside the talus. There are frequent cases of the two different series of rocks being traceable into almost immediate contact; and then the Yellaconda quartzites are dipping at high angles at the gneiss.

Faulted.

In such cases, there has been faulting; for the beds thus brought abruptly against the crystallines

are not the lowest of this series; often they are the highest. Where the talus widens out to a mile or three-fourths of a mile, thus giving thousands of feet of space for strata to turn up by crushing along an unbroken junction, faulting is not so evident. But it must be remembered that if the lower groups of the series are persistent in an easterly direction, there are underneath the quartzites at their contact with the gneiss, according to the classification now adopted, Cumbum slates, Byrencondas, Poolumpetts, and Naggery beds (leaving out of consideration the *Paupugnee*, or lowest, group of the KADAPAHS) which altogether in the main Penn-air valley must be at least more than 1,000 feet in thickness.

Northern part of Yellacondas.

The northern part of the Yellaconda range is on the contrary overlaid by Cumbum slates; and, therefore, its quartzites, of which it is largely made up, and which do not appear to differ much from those of the southern part either in appearance or constitution, must belong to the Byrencondas; or, if they are the same as the beds of the southern part, as one might be led to suppose from the non-appearance of any topographic or stratigraphic break in the mountains, they must be so by an inversion of the strata.

Possible inversion of strata.

For a long time Mr. Foote and I were unanimous in considering that the quartzites of the Yellaconda were one and the same throughout, though we had all along to meet the fact that in the southern part of the range the quartzites are overlying the Cumbum slates. To get over this difficulty there was nothing but an inversion to be brought forward: and this to some extent is shown by some of Mr. Foote's sections, which have already been given in the extracts from his notes.

Or a system of faults.

Latterly, however, it has appeared to me not out of the way to suppose that a line of fault crossed the strata of this range somewhere between that part of the range opposite to Porenaumla and the commencement of the widening out of the ridges into the Davurconda mass further north. There is no direct

evidence of such a fault or line of faults; but there are two, if not three, lines of dislocation running obliquely at the range of hills; and it is hardly possible that these should have stopped short in the sudden way represented on the map. Unfortunately, at the time of survey, there was no observation made giving evidence of the extension of these faults; and Mr. Foote has been led in his section (fig. 37, p. 222,) to admit of an inversion, while the same arrangement of the strata might as easily be accounted for by faulting.

Breaks in continuity and character of strata between Cumbum and Kullsapad.

There are again some features about the country west of this part of the range which are indicative of faulting. There is no reasonable way of connecting the group of ridges of quartzite of Porenaumla and Kullsapad in their foldings with the group of ridges further north. There is an evident break in the continuity of strata here. Again, at Iddemkall, about half way between these two sets of ridges, there is a picturesque and isolated hill, which, strange to say, is made up of undoubted igneous rock, an island of porphyritic syenite in a plain of slates. Another isolated boss of this same kind of rock occurs (according to Mr. Foote) some 13 miles due north-by-west of the Iddemkall mass, about a mile north-east of Racherla village. The immediate contact of this rock with the slates which surround it in both localities is obscured by cotton soil. Mr. Foote saw further traces of the same rock to the south-south-west of this near Giddaloor, but it is not certain whether the syenite is *in situ*. We saw no signs of alteration of the surrounding slates nor of their lie. These are the only three points in the Cumbum part of the country where igneous rock occurs; and the conclusion is, that they are the summits of peaks around which the KADAPAHS were deposited, or that they have been let in here by faulting.

There is a third case of break in the continuity of the rocks on either side of the southern ends of the series of ridges between the Kullsapad ridges and Cumbum, in the entire cutting off, to the north, of the runs

of quartz which are so very strong to the south of this. Mr. Foote says, writing of the ridges south of Cumbum :—

"As soon as the southern extremities of these valleys are attained, a great change in the appearance of the slate formation is observable in the presence of great numbers of veins of milk-quartz, many of which are of large size. These are almost entirely wanting in the northern spread of Cumbum slates, * * *. These veins occur from the south end of Moaksheegoondum hills down to the Porenaumla and Budvail valley; but the greatest development of them occurs a few miles south of the Moaksheegoondum hills."

At the same time, Mr. Foote says, that the mineral character of the slates does not change. This last point does not, however, affect the question much, as the slates on either side of the fault belong to the same series: the difference being that to the north of the line the slates of Cumbum are lower beds of the series, while those to the south are higher. In fact, the slates of the western side of the Porenaumla or Kullsapad valley would seem to be the same as those of Cumbum, the upper ones having been denuded.

Lastly, the undulation of the Moaksheegoondum ridges is complete, while that of the Kullsapad ridges is not so; the most easterly of the latter being cut off abruptly at the northern end, which could not have been alone the result of denudation. There is a ridge north of the easterly one, which looks like a continuation of it; but if it be, its apparent run into the Unkalumma ridge of beds, which are the same as those of the main hill-mass to the east, is just as inexplicable as the fact of the quartzites of the great ridge east of Kullsapad overlying the slates, while they, if they are the same, underlie these slates in Davurconda. The junction of this apparent continuation of the Chowky ridge with Unkalumma is not at all clear, and there is much fracturing and crushing of the beds as well as a rectangular twist in their strike at the southern end of Unkalumma.

The slates are dipping regularly under the quartzites of the Yellaconda up to Yerragoonta village; and they are overlying the quartzites at the head waters of the Muddavapully stream. There must then either have

been an axis of flexure between these two points, or a system of faulting by which the lower quartzites and slates were brought within the influence of denudation. Mr. Foote's north-north-west line of fault, were it continuous into the Yellaconda, would strike this area of alteration in dip, and the region of disturbance in the quartzites, at the south end of Unkalumma.

It is unfortunate that these lines of disturbance, if they exist, are not clearly displayed; and it is far-fetched to try and bring in a series of displacements on such poor grounds as are given above; but the point still remains for solution, *viz.*, that in such a short distance, there is the remarkable change from a series of quartzites overlying slates to rocks of a like kind underlying slates which to all appearance belong to the same series. A system of faults equivalent to a throw of perhaps 1,000 feet is the result of one view, while a tremendous inversion along an axis of flexure of ten miles is required for the other.

The stratigraphy of the whole field points as clearly to the south part of the Yellaconda, with the exception of that south of the Venkatigherry pass,* being made up of quartzites belonging to the group at present under consideration, as it does to the northern or Cumbum part of the range being altogether a lower series of quartzites. May not, therefore, these indications of a system of faulting in this region be taken as part of the reasoning in favour of the same conclusion?

Nemillygoondum quartzites.

On the south-western flank of the Byrenconda, the Cumbum slates are overlaid by a series of white quartzites which show strongly to the westward on the Poppanainpully plateau and again further to the south in the hill ranges of the Nemillygoondum Pagoda and waterfall.

Here the strata are generally massive white sandstones. Mr. Foote who saw most of this part of the field refers to this sub-group as follows:—

"The quartzites of this formation are very typical, generally of a pale buff-drab color, extremely compact and semi-vitreous, and showing several series of fine joints

* Taking the synclinal north of Giddaloor as a fair average representation of the thinning out of the Cumbum beds.—W. K.

by which the beds are broken up, so that where exposed in cliffs, they often resemble gigantic cyclopean walls. This quartzite formation occupies a considerable area in two principal localities on the eastern side of the Nullamullays, and forms apparently also the narrow central quartzite plateau of these mountains. There is an interesting outlier of quartzite forming a ridge immediately east of the large village of Giddaloor, which quartzite seems to belong to this group rather than to the next underlying one (Byrenconda Quartzites). The lithological character of the Nemillygoondum group is, on the whole, very constant throughout."

"In the Nemillygoondum section the quartzite occurs in massive beds from three to six feet in thickness, nine or ten of which are exposed in the cliff over which the Guntacummum river falls. These beds are here bent into a huge synclinal fold, out of which the overlying slates have been eroded, together with two or more of the top beds of the quartzites."

"The thickness of the quartzites (in the foregoing section) is apparently very much less than in the section seen in the very picturesque rocky coombe south-west of Poppanainpully, in the Bolapilly valley, where the east side of the northern plateau is well exposed. In this section the quartzites cannot be less than from 300 to 400 feet in thickness."

"Towards the north-eastern edge of the plateau, the quartzite is much cut up by cleavage planes, running north 5°—10° east, with a very high dip to the east, almost vertical in fact. By this cleavage the structure of the rock has been completely altered; the fracture has become slaty; a laminar structure parallel with the planes of cleavage has been set up; and the influence of weathering on the surface has been far greater than where no slaty cleavage has affected the quartzites. This cleavage but rarely shows in the compact, semi-vitreous, pure quartzites: indeed in most cases where quartzite is thus cleaved, numerous tiny plates of silvery grey mica are to be detected in its substance."

Giddaloor outlier.

"The outlier of these quartzites above referred to, lying to the east of Giddaloor, forms a narrow elevated shallow synclinal trough, whatever previously overlaid the quartzites having been denuded away. At the southern end the structure of the hill is extremely obscure, for although of a very hard massive variety of rock, it has been so much affected by cleavage that the bedding is not at all satisfactorily traceable. There are indications of the synclinal fold on the summit of the ridge. Further north, where the ridge widens out, the synclinal structure becomes more evident, and is quite distinct near this end of the outlier. The rock is exactly like that of the Nemillygoondum beds."

Nundycunnama and Howhoblum.

On the Nundycunnama and above Howhoblum, the representatives of the Nemillygoondum quartzites are very much as Mr. Foote has described above, *viz.*, very

compact, thick-bedded, fine-grained white sandstone-quartzites. The Nundycunnama beds are clearly and rapidly folded in sharp undulations (see sections, Fig. 34, p. 217).

Fig. 40. Section (diagrammatic) through Hoblum Pagoda, southern part of Nullamullays, Kurnool District. The pagoda is on S2.

Q1. Nundycunnama quartzites. S2. Aukiveed slates. Q2. Nemillygoondum quartzites. S3. Cumbum slates. Q3. Byrenconda quartzites.

Fig. 41 is a view of a picturesque peak at the head of the Howhoblum stream, called Mom Conda.

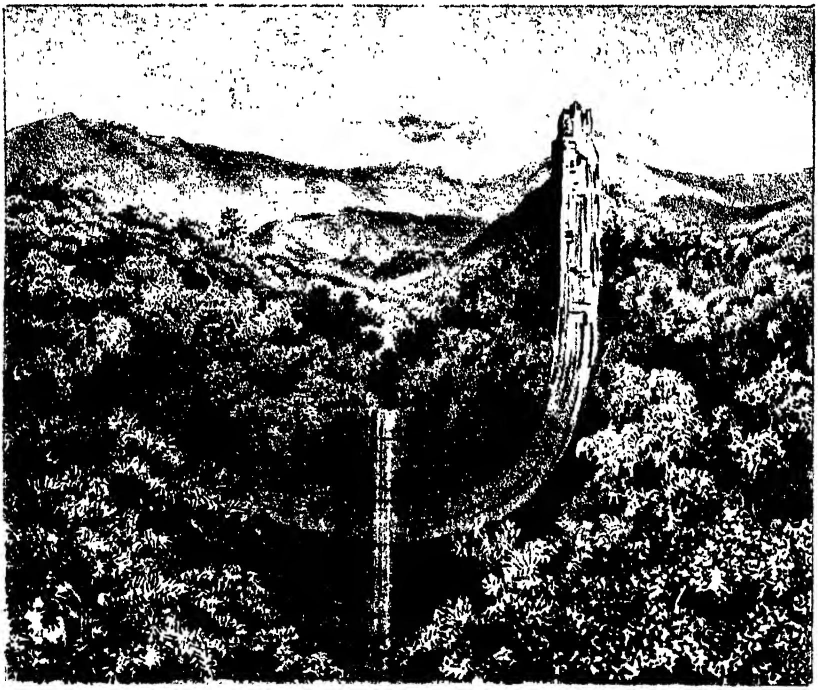

Fig. 41. Sketch of peak of Mow Conda, near Hoblum Pagoda.

Nemillygoondums seem to answer to Yellacondas.

This set of quartzites, owing to their distinctiveness, thickness, and resemblance to those of the southern part of the Yellacondas, would seem to answer to that series; but it is not improbable that they may correspond to the Porenaumla band of quartzites in the Cumbum series which thickens out tremendously to the southwards. There is no band of quartzite strata in the slates between the quartzite of the summit and those of the southern flank of the Byrenconda which might answer to the Porenaumla band, though at the same time it is clear that the Porenaumla beds have thinned out very much from what they were to the south, and may not occur at all on the flanks of the mountain referred to. It seems preferable to consider the Nemillygoondum beds as a distinct sub-group, and, therefore, representative of the Yellaconda beds.

Aukiveed slates.

The Nemillygoondum beds are overlaid in the Aukiveed or Poolalcherroo valley by a set of grey and purple glazed and talcose slates; and similarly on the Nundycunnama, where there are also overlying slates, and even quartzites topping all, which are very fine-grained, compact, and of bluish colors. These are, perhaps, more like the slate of commerce than any others among the KADAPAH slate groups.

At Howhoblum,* strata relatively in the same horizon appear in force, and are of dark-blue and purple colors, breaking up in massive rudely wedge-shaped blocks. The pagoda is built on these, the slates of the ravine having been quarried out into platforms on which the buildings were erected. The rock is coarse, and not finely cleavable, though it is very distinctly cleaved north-south with a high dip to the eastward. The bedding is very clear, and is seen along the faces of the lofty headlands flanking the ravine.

* Western flanks of the Nullamullays, behind Mootialpawd.

In writing of the Aukiveed valley, Mr. Foote notes "that the general lithological characters of the slates are, grey colors, fine grain, but not much compactness of texture."* A small bed of compact grey limestone occurs in the slate about a mile north-east of Aukiveed village. The slate beds are very much cut up by cleavage, which strikes generally north 5° east, dip 7°—5° east by south. Variations in the strike and dip of the cleavage are not at all common in this region, and none of any importance were observed. None of the slates are fit for roofing purposes. The beds roll about at low angles in the bottom of the valley, but along the sides they rise up the inclined planes formed by the slopes of the enclosing ridges at angles varying from 25° to 40°.

Higher quartzites.

There is no sign of any unconformity among these upper quartzites and slates of the Nullamullays, and it is not improbable that the slates just described are merely a band in a group of quartzites. The quartzites both on the Nundycunnama and at Howhoblum, which overlie these slates, are massive white, fine sandstones just like those beneath on the Nemillygoondums.

The Kistnah Beds.

Strata on the Kistnah.

The Nullamullay mountains are in their northern extension traversed by the Kistnah river, and may in describing this part of the country be viewed for convenience as the Kistnah range: while the rocks, evidently of the KADAPAH formation, may be considered as the *Kistnah* series. The question is, what group of the KADAPAHS they represent.

Obscure stratigraphy of Dorenall valley.

The stratigraphy of the country of Doopad and the Dorenall valley is, as already observed, very obscure. Well-marked and often very thick series of quartzites disappear or thin out westward along the latter valley, and are brought

* It is quite possible that the slates may be more compact where freshly exposed *en masse*; but I observed no fresh section by which to form an accurate judgment.—R. B. F.

close up together in the most untoward way. For example, the Innaparatyconda, which is capped and flanked in its northern slopes by a thick and massive series of quartzites, shows strata which are to all appearance dipping northwards under the slates of the Venkatreddy-polliam valley; and yet they disappear in the most mysterious manner to the east and west. They may, of course, be an intercalated series in the Cumbum slates, answering to the curious oval ridge of quartzite which curves round past Chapulmudgoo; but then again it is impossible, owing to breaks in the continuity of the strata in the neighbourhood of Doopad, to say what the Chapulmudgoo band may be representative of in the country south of Doopad, where there are again bands of quartzite of the Byrenconda beds—unless it be of Byrencondas themselves. This seems the most probable solution; and that the continuity of the beds is in this region broken by hidden faults and crushed; and that their regular outcrop southwards has been here crushed out of form. In this view the slate south of Chapulmudgoo must belong to the group subjacent to the Byrencondas, while the Chapulmudgoo beds are Cumbums proper.

Kistnah beds overlie Cumbums.

It then turns out that the *Kistnah beds* overlie the Cumbums very clearly along the south-eastern, or Doorgapa-conda, slopes of the hills; and thus they may answer to the Nemillygoondum or Yellaconda beds.

Traverse of the Kistnah range.

On working up to and over the Kistnah range by the stream flowing down to Veerabudrapore, or Venkatreddy-polliam, the coarse dark colored clay slates, &c., are overlaid by a thick and sharply undulated set of quartzites, above which again are more earthy and sandy, fine, red and purple slates and shales, at the top of which is a thin band of quartzites near the crest of the steep slope, which to the westward forms the summit of Doorgapa-conda. Over these again comes a thin series of red, sandy, slaty shales, and then the highest massive and white quartzites, which form the

upper surface of the great plateau-range of hills down into which the Kistnah has worked its channel.

Unconformable to Cumbums.

This series of quartzites, slates with intermediate bands of quartzites and hard quartzose beds, and quartzites again, is complete in itself in the great plateau; and it certainly seems, along the northern part of the Dorenall valley and in the upper part and north-west slopes of the Waumyconda range, to be unconformable to the Cumbum slates; while at the western end, or in the Irlaconda, the series overlies spotted shales and traps, which certainly appear to be Tadapurtees or Poolumpetts. In the Waumyconda range, the strata have been crushed up and folded with the slates, so that they seem to be conformable with them; but it is quite evident in several of the valleys that they overlie different bands of the Cumbum slates. For instance, in the neighbourhood of Kakeralla pass, and in the much folded part of the range east of it, the quartzites are sometimes immediately overlying limestones, and again for long distances overlying slates of different kinds.

Sreeshalum plateau.

In traversing the basin-shaped plateau north of Doorgapaconda the upper part is found to be entirely of the highest white quartzites, and these extend westwards up to and beyond Sreeshalum* or Parrawaltoon Pagoda. At Shigaram Pagoda (the highest point of the plateau) a few miles east of Sreeshalum, there is a break in the uniformity of the flat lie of the beds, due to a sharp anticlinal which becomes a contorted fold further north in the head valley of the Kolumnullah. The great river to the westward of Doorgapaconda has cut down through these quartzites and the

* One of the most sacred places on the Kistnah, or (as it is often called by the people) Kishnah or Krishna, to which enormous numbers of pilgrims resort annually from great distances. When I was there in February 1869, at the commencement of the pilgrim season, most of the people assembled were from the Beejapoor country. An interesting account of this pagoda is given in the Madras Jour. Lit. & Sci., 3rd Ser., Pt. 2, p. 126, 1866, from the late Captain Nelson's notes. W. K.

great thickness of slates, &c., beneath, producing a most picturesquely trenched area of elevated land.

Quartzites.

The best sections are exposed about Sreeshalum itself, and a description of the rocks here seen will suffice for all. Highest are the coarsish, light colored quartzites, grits and sands on which the pagodas are built. These shade down by thinner beds into sandy flags and slaty shales of no great thickness, some 40 or 60 feet, and then come other coarse grits and sands, and whiter and finer beds in another thin band.

Kolumnullah slates.

Subjacent to these generally white quartzite sands, and grandly exposed in the course of the river and its tributaries among the hills west of Sreeshalum, comes a thick series of red and purple earthy and sandy slates, with compacter beds, and some thick intercalated bands of quartzites, which must be, in the Kistnah area, from 600 to 800 feet in thickness. These slates are very well displayed in the valley of the Kolumnullah, to the south of Sreeshalum, on the pilgrims' road from the Kurnool district. After ascending the ridge of quartzites above Peddacherroo,* one descends over the slates, which are here dipping down to the north-east rather irregularly. They are red, or sometimes black-brown, sandy, earthy, and occasionally smooth and compact, with numerous thin beds of tesselated and ferruginous sandstones. To the left of the road there is a grand flat-topped hill formed of this group of rocks, and scarped all round the summit in cliffs of 100-200 feet of the upper quartzites. Near what appears to be the bottom of the valley, the ferruginous quartzites and tesselated sandstones come to the surface again tolerably flat, and last up to the brink of a precipitous-sided gorge which the Kolumnullah has here cut into the lower beds, the same as those at the base of the Peddacherroo ridge. The stone-built path winds down to the bottom of this ravine,

* A large tank in the midst of the jungle past which the pilgrims' road from Kurnool runs. There is no village now, only a few huts of Chensullah people, a peculiar tribe dwelling in a half nomadic style on the Nullamullays.

where the earthy purple and red slates are found to be resting on coarse dirty-colored massive quartzite-grits. These form the floor of this tributary of the Kistnah far back up its course. Thence the path climbs up over the outcrop of the whole series of slates to the plateau of upper quartzites on which Sreeshalum is built, as in the following diagrammatic section :—

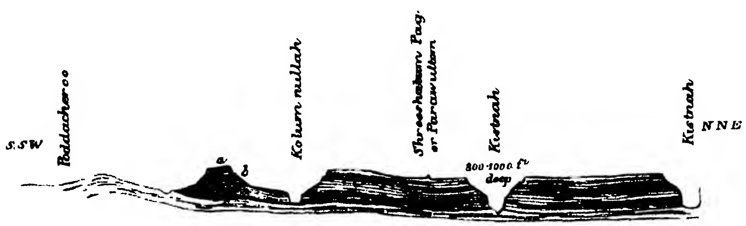

Fig. 42. Diagrammatic section across the Sreeshalum plateau. Hor. Scale 2 miles to 1 inch.

a.—Sreeshalum quartzites with intercalated slates ... ... }
b.—Kolumnullah slates with tesselated sandstones, &c. ... ... } *Kistnah Beds.*
c.—Irlaconda quartzites ... ... }

None of the beds in this part of the field are at all such typical slates as are seen in other localities. They are here essentially earthy slates, very well cleaved, but with no obscurity in their lamination. They are often shaly enough to give fine opportunities for exposing organic remains if there were any.* There is such a grand display of these strata here that they may be called after the Kolumnullah, so as to distinguish them from Sreeshalum quartzites above.

To the east of Sreeshalum beyond Shigaram Pagoda there is a sharp roll up of the strata by which the sandy flags and shales beneath the upper or Sreeshalum quartzites become exposed, but these soon roll down again to the east, and then the rest of the river-valley is of the uppermost beds. The lie of the strata is in a shallow basin or trough, rising up north and south, and for part of the distance, up to the east—as in

* I examined the beds frequently in my climbs up over these slates, but could find no trace of organic remains.—W. K.

the Goonyconda on the eastern side of the sharp turn of the river to the north before it enters the Palnád*; but there is throughout a general dip to the east. The river flows nearly in the axis of this flat synclinal. At the eastern end of the plateau-range the Goonyconda is capped with the upper white quartzites, and these with the lower strata are continued eastward in the Waumyconda range, or north-east spur of the mountains, and then further north in the hills flanking both the banks of the Kistnah, until they are covered up by the limestones, &c., of the KARNÚLS† in the Palnád.

Irlaconda quartzites, their great thickness to the west.

At the bottom of the Kolumnullah, the stream flows over coarse dirty brown grits and sands in thick and thin beds. To the westward of Sreeshalum these strata hade up from under the great thickness of red and brown slates, &c., as a great succession of beds, well exposed in the bed of the Kistnah, rising up to form the mass of Irlaconda hill. One may walk for miles all along this part of the river passing over the edges of these grits, which are dipping at 5° to 8° eastward; and there is only one anticlinal and synclinal undulation between a point north of this hill and Verabudr Droog. This would give a thickness of 1,200 feet at the lowest computation.

Overlie Tadapurtee slates.

At Verabudr Droog, the west end of the Irlaconda range, these lowest quartzites overlie mottled shales with trap and limestones which are exactly like the strata in the Penn-air slates; and they eventually to the north thin out over these, on to the gneiss of the Hyderabad territory.

North-eastern edge of field.

Following these quartzites again in their north-easterly run along the northern side of the Kistnah basin, it is found that in the neighbourhood of the Dindee river, where

* Western part of the Kistnah district.

† There are two isolated patches of these limestones close down on the right bank of the Kistnah below the western flanks of the Goonyconda.

the Kolumnullah slates again come in over these beds, the thickness as the contact is hardly more than one hundred feet at the most. Further still in this direction, or along the left bank of the river as it flows through the Palnád, the quartzites are very thin and show evident signs of a shoreward thinning out of the group. They are here overlaid, not far from their boundary on the gneiss, by limestones of the KARNÚLS.*

Conglomerates.

No strong conglomerates were observed in the Kistnah area, except in a few localities. The principal one among these is in the Timmerycota range of hills; on the right bank of the Kistnah in the western part of the Palnád, there are here coarse conglomerates and pebble beds of worn fragments apparently of the peculiar non-descript red and dark-colored striped quartzose rocks on which they are resting. The lowest beds here are dark-colored, black and purple, coarse sands full of pebbles and small shingle of red, black, and striped, hard, compact quartzite, or quartz-rock, derived from what appears to be a much older series of rocks.†

There are again pebble beds and conglomerates of a somewhat similar character at the bottom of these quartzites in the western part of the Kistnah range, cropping out along the crest of hills south of Verabudr Droog; only in this case there are none of the striped rocks of Timmerycota to be seen. At Verabudr Droog these pebble beds are overlying purple and grey slaty shales of the next lower group. Lower down stream, in the bed of the river, some two miles east of the Droog, there is a splendid show of these pebble and conglomerate beds,

* There must, of course, have been a good deal of denudation before the deposition of the KARNÚL limestones; but everything indicates that there was a great decrease in the thickness of the *Kistnah beds* from what it is at Irlaconda.

† The Timmerycota Trigonometrical Station and that part of the back-bone of this range of hills are made up of these striped quartzose rocks, which are striking round in a curve, and are more or less vertical along this striped, or foliated, or laminated structure—it is not clearly evident what the striped appearance is due to. The overlying beds are resting unconformably on these rocks.

the contained fragments being of all colors, principally reds, while the flowing water has polished great surfaces of rock until the river-bed is quite a smooth and brilliantly colored mosaic of pebbles of chert, jasper and quartzite, in a generally flesh-colored ground. Along the north-western edge, on the Hyderabad side of the river, the lowest beds are generally coarse sandstones and grits with only a few pebble beds; while eastward of the Dindee river, there are a good many bands of red sandy shales associated with the thin beds of quartzite.

Floor of crystallines.

From the Dindee, eastwards, the lowest beds are resting for the most part on an almost perfectly flat floor of crystalline rocks (granitoid gneiss). This junction of the two different series of rocks seems quite strange after the generally undulating, or irregular, bottom on which the sedimentaries are seen to lie in the western scarps from Kurnool southwards. The granitoid gneiss itself may often be taken at a distance for a lower conformable deposit, there being locally in it some semblance to flat bedding. It seemed to Mr. Foote and myself that here were traces of a plane of marine denudation, over which these higher beds of the KADAPAHS had been deposited. The subsequent sub-aërial denudation has produced no surfaces like that on which these quartzites were deposited in this part of the field.

Traces of marine denudation.

Irlaconda beds in Waumyconda.

In the Waumyconda range on the south side of the Palnád, these lower quartzites are again seen, but not to any great extent. They form apparently the set of quartzites which is below the series of slates of which the quartzites of the Waumyconda itself form the capping; and they are very possibly the lower band of quartzites seen in the pass which leads from Mellavagu down to Karampudi in the south-eastern part of the Palnád. It is quite impossible to speak decidedly as to the different bands of quartzites in the Waumyconda, for they are broken very often in their outcrop, and they are folded back on each other, particularly about the middle of the range.

The eastern edge of the Palnád is formed of ridges of quartzites overlying limestones and slates at certain points; while at other points they are in turn overlaid by these very limestones. These quartzites seem certainly to be of the KADAPAH series; but it is difficult, if not impossible, to say whether they are all of one group, or of several, as the ridges are much broken by east and west cross-faults, in addition to north and south ones.

Kistnah beds on the eastern edge of Palnád.

The lowest quartzites of the *Kistnah* beds can be traced very clearly along the north-western edge of the field up to, and round to the south of, Batavole or Juggiapett; but the southerly run is broken at the crossing of the Kistnah. It is, however, very probable that some of the ridges further south down to Nakarikallu are of these lowest quartzites. A great overlying series of quartzites and slates shows in the Pulichinta mass of hill, in the promontory south of Batavole, a description of which will be found in Mr. Foote's notes.

The most difficult question, however, in the Palnád is to group the limestones. As already related, the limestones of the western part of this field are to all appearance KARNÚLS, but in the eastern part of the field identical limestones underlie what are clearly KADAPAH quartzites, and in parts of the field overlie these also.

Limestones overlying and underlying these.

It is impossible to account for this anomalous position of the rocks except by inverted folds, which style of folding certainly exists in the great inversions in the Waumyconda range; and which may have been prolonged into the smaller Nakarikallu ridges. In this way, it is supposable that all the limestones up to the eastern ridges are KARNÚLS, and so I have considered them; but under this view there must follow an enormous inversion of all the slates and quartzites in the promontory mass of hills. I must confess myself quite at a loss to explain away such untoward stratigraphy.*

* Mr. Foote's notes on this area are given in Appendix, and may prove a key to the satisfactory solution of this difficulty.

PART IV.

Chapter 1.—Boundaries, Faults, Contortions, &c.

Of the eastern faulted boundary.

Whether there be such continuous faulting as Mr. Foote has inferred from his survey of the eastern edge of the country, or that there are only local dislocations at frequent points along this line, it is certain that there was a considerable amount of faulting with down-throw of the rocks on the west side of the line; which down-throw, even at the southern end, amounts to at least 1,000 feet. Further north this was much increased, up to some 20 miles north of the Penn-air, where the throw amounted at least to the thickness of the *Nullamullay* beds and their overlying quartzites in this part of the Yellaconda ridge, at least 2,500 feet. North of this again the amount of throw must have decreased quickly, for only the Nullamullay beds seem to have been affected, and they are thinning out in this direction.

Throw and its direction.

It becomes then a matter of interest to know in what manner the rocks were displaced by these faults, for there are, particularly in the more northerly part of the field, certain anomalous relations of these features not at all consistent with the resemblance of the strata to other groups in more typical parts of the area, or with the actual order of the beds.

It will be shown presently how these peculiar instances of superposition and resemblance render the Palnád or extreme north-eastern field of the KADAPAH and KARNÚL rocks a perfect puzzle in the attempt to correlate its strata, of which Mr. Foote and I are only able to advance very doubtful solutions.

There was undoubtedly a down-throw in nearly every case on the west side of the faults; but it is not at all clear how the plane of fracture haded, or dipped. The apparent conclusion is that the fault-

plane was either vertical or at some inclination in the direction of the down-throw side, *i. e.*, with a hade to the westward. There is not a single section along the whole of this line showing how this really is, and we are thus driven to speculate on the matter.

Considerations as to the underlie of the faults.

The whole series of KADAPAH rocks evidently occupies a much less space (in the Nullamullay area) from east to west than it originally did, in that the groups are now undulated and folded up against themselves and one another. Therefore there must have been some movement to have brought this about.

The folding of the strata is multiplied the nearer the eastern edge of the field is approached, while on the western side, the beds are lying comparatively undisturbed. Therefore the movement must have come from the side where the folding is greatest. The movement then was from the east.

Let the movement be kept in action, and eventually the most bent and stretched strata must fall over with a hade to the eastward, and possibly break and slide over one another in the direction of the planes of folding.

Reduplication of strata.

In the lie of the strata under discussion the folds are stretched and bent over on one another in many sections exposed to view in the side valleys, but the fracturing of such folds is not so easily or frequently recognizable. There are, however, examples in the Waumyconda range of hills* where there is certainly reduplication of the strata to a good extent, as in the following sections (see figs. 40, 41, 42, 43), wherein the band of limestones near Kakeralla, which in the mountain mass to the north-east is very sharply bent back on itself, is in the lofty quartzite ridges to the south-west absolutely doubled into what appears to be one set of beds dipping at an angle of 60° to 70° south-south-east; or else this sharp bend is fractured, and the two

* South-eastern side of the Palnád.

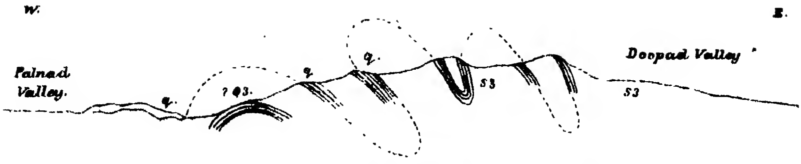

Fig. 43. Sketch section across Waumyconda range, east-north-east of Kakeralla.

S 3. Cumbum slates with limestone. Q3. Byrenconda quartzites.

The sharp double of the quartzite band in the middle of the ridge is very clearly displayed in the side valleys.

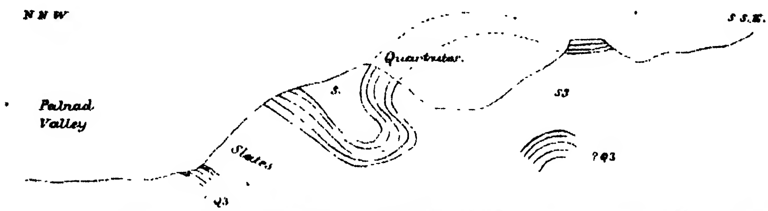

Fig. 44. Section displayed on the eastern side of the deep lateral valley leading up to Waumyconda.

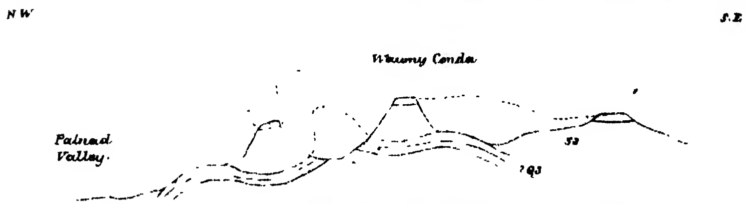

Fig. 45. Sketch section of the Waumyconda. The quartzites capping the lower hill to the north-west correspond to those at the bottom of the inversion in the section above.

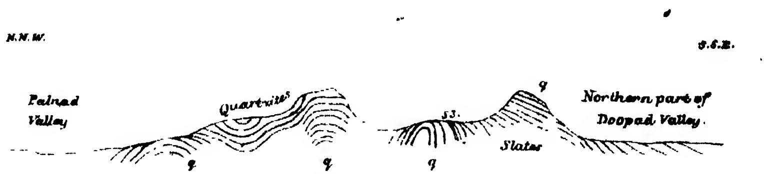

Fig. 46. Sketch section across the Waumyconda range, north-north-west of Marripalem. The position of the quartzite bands in the KADAPAHS is as yet doubtful.

arms of the curve have slid over each other. There is every sign of a fault along here—in the odd juxtaposition of the limestone and different bands of quartzite at such high angles, and the non-appearance in the

slates between the ridges and Murryvamla of any quartzite of a similar kind to the quartzites which occur to the south. The limestone is highly altered along this line, very crystalline and of a nearly pure white color. The quartzites now lying over it are likewise much cleaved and contain little, if any, traces of detrital origin.

It must also be taken into consideration that there is an apparent inversion of the strata at many points along the northern part of the Yellacondas, and again in the eastern part of the Palnád. Mr. Foote is of decided opinion that the greater part of the Yellaconda range towards Cumbum shows cases of inversion, as displayed by his sections (see sections figs. 36, 37, pp. 220, 222): and on this account we were for a long time led to consider that the quartzites forming the main mass of the eastern ridges from the parallel of Porenaumla, southwards to the Pennair river, were overlying the slates of the Budvail valley by a great inversion. This may, however, be explained by a line or lines of faulting, and the quartzites and slates would then appear to be in their proper order.

In the Palnád area, however, the case is different, for in the eastern ridges, there are cases of limestones overlying and underlying the same series of quartzites in different parts of the same ridge, which necessitates an inversion of the strata. Nor is this at all an improbable arrangement, for there are actual inversions to be seen in the Waumyconda range, of which these smaller eastern ridges are only prolongations.

Two regions of intensity of undulation.

There are then two regions in which the folding of the strata along or near to the eastern edge of the field is of different intensity. In the north the undulations are repeated and the beds are inverted. To the south, or from the parallel of Porenaumla, if there be no inversion,* the curves are, as a general

* Mr. Foote supposes inversion. I am inclined for a system of faults as shall be explained further on.—W. K.

rule, either simple with a vertical axis-plane, or with one side more or less approaching the vertical.

Direction of throw not necessarily with a hade to the westward.

In both regions there are long lines of dislocation: the question then is as to the inclination of the fissures. The general rule is, that the fault must hade towards the side of the down-throw, or in this case that the inclination of the faults must be to the westward; and with this idea Mr. Foote has given all his faults, in section, with this dip.

On the view that fracture resulted from folding of beds.

It seems, however, on looking into the matter, that the hade of the fissures may be really in the opposite direction, in most of the long lines of fault at the base of the northern Yellaconda and in the country northwards to the Kistnah. It would be so supposing that the fractures were consequent on the pressure that produced the folded flexures of the strata. Pressure and contortion may indeed be the secondary results of faulting: thus here, supposing the faults to underlie to the west, in the direction of the down-throw, under such circumstances the area of country depressed would have to occupy smaller space, and the strata adjacent to the fault might be thus crushed into folds, which might even have their curves toppling to a certain extent, in the direction of the throw. It is doubtful, however, whether the amount of folding produced in this way could at all approach that which is now exhibited in this part of the field; not at least without a much greater depression than seems to have been superinduced on the rock groups. In the generality of cases here observed of faults simply across the bedding, and not cases of fracture from extreme curvature of the beds, there is little folding of the strata for any distance from the plane of faulting.

Original and subsequent lie of strata.

The basin of KADAPAH rocks originally, in all probability, existed as a broad trough (fig. 47*a*), of which the western side has remained pretty much the same as to

the lie of the strata until now, while the middle and northern parts of the eastern side have been crushed up and now occupy a smaller space, as in fig. 47*b*.

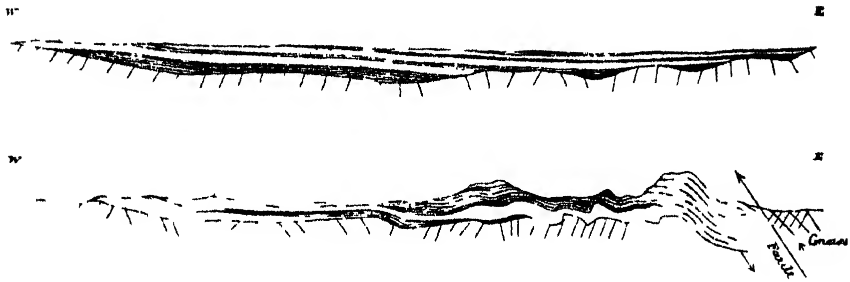

Fig 47 *a* and *b*. Ideal sections of the KADAPAH ROCKS, as deposited, and after contortion.

The western side was then comparatively stationary, while the folded strata of the eastern side indicate where the greatest amount of movement was and whence it came.

Vertical throw inconsistent with folding.

Wherever there has been faulting when the beds are clearly inverted, a vertical fault is inconsistent with any fracture arising directly from the curvature of the beds, for this fracture would be preferably along the axis-planes of curvature; similarly in the case before us a fracture with a hade to the westward would be as incompatible with curves of the actual form; such could only take place in simple curves, or in such as leaned over to eastward. Many of the faults in the area now treated of, and particularly the cross-faults, are doubtless not referrible to flexure; but a great many doubtless are, and in such cases it seems more reasonable to look on the planes of dislocation as hading with the axis-planes of flexure, which in the northern part of the field are reversed, and thus give a tendency for the older groups, and the much older crystallines, to be found overlying the newer rocks. It is true that no cases are exposed of the gneiss lying on the quartzites; but the gneiss is very close to these rocks, which dip down towards it.

This kind of movement is in accordance with the form of the curves in the Yellaconda, and with the fact that the anticlinals of the domes to the north having a higher dip on the western side than on the eastern, and also with the curved lines of much of Mr. Foote's system of faults. These curved faults are nearly always quite parallel with the strike of the beds, as in the Vinukonda dome, &c. Now, it is conceivable that fractures which would in folded flexures run with the axis-planes of those folds, might, if we may suppose them prolonged (downwards) into quaquaversal undulations, or domes, run with the bedding on either side of the long axis of the dome, rather than right through or across the middle, for there would be then planes of weakness, and a tendency would exist for the fractured masses to slide along the bedding.

Under-throw in accordance with present lie of strata in northern part of area.

CHAPTER 2.—ECONOMIC RESOURCES.

The resources of the rocks of the Cuddapah and Kurnool districts have already received incidental notice in the preceding pages; and, considering the great area and thickness of the two formations, the more valuable of these, as far as they are known and have been developed, are not of very extensive or frequent distribution. It must always be borne in mind when treating of the value of Indian mineral resources from an English point of view that there are always great drawbacks to be encountered in the way of climate and in the means of approach to the field of these resources whatever they are.

Value of these must depend greatly on the developer.

For example, under the Mogul dynasty, the different metallic ores, and the more rare and precious diamond, were largely sought after and worked in these districts; and the results, on the whole, very possibly paid the rulers of the country well. Under such circumstances, the

Under the Mogul dynasty, or in a Native point of view.

climate of the country and the difficulties of approach were of no account, for life was held cheaply.

Non-development in the present day no sign of poorness.

In the present day all the old workings in these rocks within the British territory are deserted, with the exception of a few diamond mines in and around the Banaganpilly country; yet it is almost certain that they were deserted not on account of the ores or the precious stones having been thoroughly worked out, but because there are now no natives in the territory able or willing to speculate in mining, and that the climate, means of approach, and want of labor are serious difficulties in the way of the development of the country being taken up by Europeans.*

European attempts at mining failures hitherto.

It is true that Europeans have attempted the workings of mines in these districts (notably J. Ouchterlony, Esq., of Ootacamund, and the old firm of Hart and Simpson in Nellore), but these all resulted in failure, principally through expenditure on 'plant,' failure in health of the European or East Indian subordinates, and general mismanagement, which last seems to have hitherto been the general cause of failure in nearly all English-connected mining schemes in India.

Within the last few years Nerjee stone paid best.

Perhaps the best paying resource in the KADAPAH and KARNÚL rocks within the last few years has been that of simple building-stone. As already related, Mr. E. W. Barnett, the principal contractor on the north-west line of the Madras Railway, has made extensive use of the limestone from his quarries at Nerjee, some 30 miles west-north-west of Cuddapah. In fact, so useful has this stone been to him that he has carried it in

* Mr. Richardson of Madras has only ventured to take up the old diamond mines near Cuddapah on the very favorable rent of Rs. 100 a year, and yet there are accounts of two diamonds having come out of this field which were eventually sold for £5,000 and £3,000 each.

his material-trains up to Gooty for the railway station at that town. The present great value and use of this stone can, however, be only temporary, though it will always be of value, now that the railway runs close alongside the quarries, and that flags can be much more easily made of it than of the gneiss, which has hitherto been so used in Madras and elsewhere within reach of the railway.

Principal resources: Diamonds.

The main resources of the country are,—diamonds, copper, lead, iron, and building materials. The field of diamond-bearing deposits has been described, and its exposed area is delineated on our maps. Of course the preferable regions for seeking the gems will always be in the neighbourhood of the old mines: and there is no reason to doubt but that new workings may be quite as profitable as the present ones. Preparatory trials may be easily made anywhere in the area mapped; preferably in the rock *in situ*, as is the case at Banaganpilly. There is, of course, always the chance that gravel deposits in the valleys below or in the neighbourhood of the Banaganpilly outcrop may contain diamonds; but these deposits are very local, and it is difficult and expensive working in deposits which are so liable to be flooded.

Deposits indicated on map.

Diamond-mining under Europeans.

At the best, however, diamond-mining for Europeans would, as far as we can see, be a very risky speculation in this area; the natives are most patient, and their expenditure on such works is very small. There appears, however, to be always a sufficiently remunerative supply of small and rough diamonds obtained to keep the present contractors working on from year to year. There is no account to be obtained of their having found any valuable diamonds: and it is hardly to be expected that they would volunteer the information. That Europeans, or a mining business organized and paid for by them, should be able to exist for a long time under what certainly seems a generally slow form of making money (with, it is true, occasional chances of a magnificent find) is, we fear,

incompatible with the present desire among our countrymen of making money in the rapidest way possible.

Favorable under certain conditions.

For people, however, who are content with a slowly paying transaction, who are willing to lead a hard life (for all Indian works must be personally looked after by some of the interested workers), and who have capital sufficient to last some years, diamond mining would pay in these districts.

Copper.

There are only the merest traces known of copper or copper workings; and these had been visited and reported on long previous to the investigation of the Geological Survey. With the exception of one locality in the Nellore district, which is on the CRYSTALLINE rocks, these old workings are in beds of the KADAPAH rocks.

Oondootla plateau.

In the Gooman Conda denuded valley on the northern flanks of the Oondootla plateau,* there are remains of old copper mines and traces of copper among the quartz veins and trap, which here traverse the Tadapurtee slates. Mr. Foote refers as follows to this locality:—"The quartz veins occurring in the KADAPAH rocks of the Calwa hills, though small in size and length, are interesting because of their being slightly metalliferous. The largest and longest of them occurs running diagonally across the Gooman Conda valley. It is here and there of mottled appearance, owing to stains apparently due to slight films of chlorite or talc. It is traceable for a length of nearly three miles along the centre of the valley, and has been worked by pits at various points in search of copper ore. At the western extremity, and immediately south of the hanging wall of quartzite at the west end of Gooman Conda, is an old pit, upwards of 20 feet deep, hewn into the solid rock, which is an abandoned copper mine. The evidences of copper ore consist in fragments

* Between Kurnool and Nundial.

of quartz scattered through the rubble talus and covered with thin films of malachite. A small specimen of azurite was also found, and another showing a trace of purplish copper pyrites. In the pit the vein-stone has been entirely worked out, leaving vertical walls of the highly indurated slate rock which occurs so largely in the bottom of the valley. The villagers could not tell us when the mine had been last worked.

"In the deep bay in the hills east of Somadulpilly (further west-south-west) are two small white quartz veins, running east-north-east, west-south-west. These are about a quarter of a mile apart. In the northern one traces of copper were also observed in the shape of specks of copper pyrites of yellow and, in one specimen, purple color, together with thin films of carbonate of copper, which also occurs in minute beautifully green acicular crystals in a few tiny cavities. This small vein, which hades or dips to the north at an angle of 85°, is from 4½ to 5 feet thick, and well exposed in the bed of a small nullah. The beds of shale traversed by it have here a slight dip to the south."

North of Vinukonda dome.

The next locality of copper ore is on the eastern edge of the field immediately north of the Vinukonda dome. There are the remains of old workings here which were opened up in thick beds of very hard fine-grained whitish quartzite. All that is seen now are stains of green carbonate of copper, and the merest traces of the same mineral in the very thin strings of white quartz which are traversing the quartzite in all directions. Mr. Foote says of this locality :—

"In a bed of very coarse granular quartzite occurring close to the ruined village of Gantlapalem, at the north end of the Vellatur eroded dome-valley (Vinukonda dome), traces of copper occur in the form of malachite and azurite films on the surfaces of the joint planes. In former times extensive mining operations were carried on here, many large pits remaining. This is the old Agingundala copper mine men-

tioned in Dr. Heyne's Tracts on India. The mine is quite abandoned at present, and the adjacent village of Gantlapalem an extensive ruin."

Nullamullays.

Fair traces of copper are again seen in the rocks of the old lead mines at Jungumrajpilly in the Nullamullays, some few miles north of the road from Nundiallumpett to Budvail. These were only cupreous stains and apparent impressions of crystals of copper pyrites and faint traces of native copper. These occur in strings of white quartz, which are striking through beds of silicious limestone. The fissures of deposition run north-north-east, south-south-west, with a dip of 60° westward, while the strata are at 50° east by north.

In the CRYSTALLINES on east side of field.

The best traces of copper ore in the area under description are not, however, in the NEWER METAMORPHICS, but in the CRYSTALLINE or gneissic series, just outside the eastern boundary. This locality is that which was worked many years ago under the auspices of the old firm of Messrs. Hart and Simpson of Nellore and J. Ouchterlony, Esq., of Ootacamund. Mr. Charles Æ. Oldham examined this region and thus writes of it:—

Copper in the Nellore district. C. Æ. Oldham's notes.

"In the Nellore district, I have noticed copper ore as occurring in one locality only. Near the village of Gunnypenta, close to the northern edge of sheet 77, about 12 miles north by west of Ingemoor (long. 79° 37′), copper ore was quarried to some small extent many years since. At the time of my visit (June 1863), the small pits from which the ore was dug were filled with water, which prevented me from seeing satisfactorily the mode of its occurrence; but, as far as I could ascertain from observation and inquiry, there seems to have been a narrow band or bands of the ore, the green carbonate, running through the hornblende-schists which are the prevailing rock here. A considerable amount was extracted, and then, partly from the vein proving less productive, probably thinning out, and partly from the

influx of water, rendering the extraction of it difficult and too expensive, the working was abandoned.

"One or two other small pits were also dug in a north-west direction (north of the stream) at a few miles distance. But these were said to have been comparatively unproductive. They also were filled with water at the time of my visit.

"I was able to procure only small and poor specimens of the ore, scarcely sufficient even to indicate its character: enough, however, to show that it was the green carbonate of copper; and one or two specimens, though small, exhibit the usual appearance of malachite, tolerably massive and botryoidal in structure. There is, I think, reason to suppose that at least in small quantity, the ore continues for some distance in a south-south-easterly direction, as I traced the hornblende-schists in this direction, and containing, at the distance of three quarters to one mile from the most southerly pit, green carbonate of copper in small quantities. Here it occurs chiefly in thin laminæ, or in a semi-crystalline powdery form between the laminæ or beds of the hornblende-schists, also disseminated in small but harder pieces in quartzose bands in the schists; it would seem to be continuous so far along the strike of the beds, which is here about north-north-west, vertical or rolling over at very high angles.

"In hornblende-schists on a tank-bund west of Calegherry, very nearly in the direction of the strike of these beds, I found traces of the same green carbonate, occurring in similar form, both as a semi-crystalline powdery incrustation and in a more massive shape as tolerably compact malachite. I could not, however, trace these small specimens to their locality, though the stone was said to be thrown up from the bed of the tank.

"In somewhat similar hornblende-schists close by, exposed in *bowries*, &c., I could detect no trace of the metal, nor could I find any occurrence of ore, as a connecting link between this and Gunnypenta,

although the hornblende-schists and quartzo-hornblendic gneiss are frequently well exposed."

The copper ore of the denuded valley of the Oondootla plateau is well worthy of examination: only it has this disadvantage that it is the only ore occurring here. In the Jungumrajpilly region, however, the ore if it be of any extent, of which there are no satisfactory evidences just now, would be worked out whilst the apparently much more extensively occurring lead ore was being mined.

The traces of ore north of the Vinukonda dome are not sufficiently rich to justify an attempt at mining, considering the out-of-the-way and deserted locality.

There are other traces of copper on the eastern edge of the field between Vinukonda and the Goondlacumma river; but they are extremely faint. The CRYSTALLINES of the Nellore country further south also contain traces; but these are in the eastern part of the Raepoor Taluqs, well outside the area of the present description.

Lead mines in Nullamullays.

The most favorable-looking and best known metalliferous regions in the Cuddapah field are the lead mines of Jungumrajpilly and Buswapoor or Gazarpully in the Nullamullays.* Both these localities are now deserted and overgrown with jungle; and they are in feverish regions, where during the healthy season, there are few local means at hand for the working of the mines. That of Jungumrajpilly is the best locality, as far as health and supply of labour are concerned, for there is the village close at hand. The Buswapoor mines are far from any village, in what is at present a tiger-infested tract of the Nullamullays,† and badly supplied with water.

* These have been reported on by P. W. Wall, Esq., the then Government Mineral-Viewer, in the Madras Journal of Literature and Science, Vol. XX. N. S., pp. 279-304: 1859.

† The tigers can, of course, be got rid of; but when I was there in the healthy season, that is, in the hot weather when the forest is leafless, there was only a little pool of water near the old workings, at which the wood-cutters fill their water-skins. The water was thick, dirty, and had a strong metallic taste; it is the only water to be got for many miles round.

In both regions, the ore, sulphide of lead, occurs in silicio-calcareous beds of the same slate series, *viz.*, the Cumbums of the *Nullamullay* group; but the more favorable metalliferous regions are in the Jungumrajpilly region.

Buswapoor mines.

The Gazulpully or Buswapoor mines are in the wide valley, on the western flanks of the Nullamullays, where crossed by the Nundycunnama pass, at about two miles north of the fifth mile on the high road from Buswapoor or Gazulpully, which villages are on the edge of the Khoond-air valley. There is a broad and deep gully or quarry, which has been cut in the silicio-calcareous beds occurring among the slates here, and which was evidently the old Mogul excavation. No traces of lead were seen in this trench, which was quarried along the bedding. Some short distance east of this, on low undulating ground of thinner flags and slates, a series of holes had been sunk in the strata, latterly by Mr. Wall's workmen, possibly on the site of old pits which had been filled up. However, the debris from these pits is still alongside the holes, and a good part of it is sulphate of baryta, which is full of strings of granular and massive galena. The last explorers had evidently taken away all the best specimens. The lead seams evidently to occur here in the same way as at Jungumrajpilly, *viz.*, in the north-north-east, south-south-west fissures of jointing.

Jungumrajpilly.

Jungumrajpilly is on the pass of that name, across the Nullamullays, some miles north of the road from Cuddapah to Budvail. The old and now deserted lead workings are at the south end and east side of a low ridge, just north-north-east of the village. The pits or galleries have been excavated between beds of dark grey silicious limestone, which is impregnated with strings of white and dull blue quartz. Granular sulphide of lead is disseminated in very small quantities through the blue quartz. In the white quartz are faint traces of copper. The exposed surfaces of white quartz are pitted all over with impressions of

octahedral crystals, and are stained with brownish black ferruginous coloring. The strings of quartz have been deposited in north-north-east south-south-west fissures having a dip of 60° westward; the strata lying at 50° to east-by-north. The exposed partings of the beds are filled with a brown earthy breccia or conglomerate* of minute debris of ferruginously blackened quartz in a matrix of ferruginous kunkur. The old workings are to a great extent filled up with the excavated fragments of rock, and are now overgrown with jungle.

Other beds of the same silicious limestone, also impregnated with strings of quartz, occur at short distances to the westward, but no traces of lead were seen in these.

Further south and west of Jungumrajpilly, there are again numerous old galleries excavated in the same series of beds, which were visited by Mr. Oldham and found to contain traces of lead occurring in the same way. He writes:—" South-westwards of Jungumrajpilly, entering the pass west-south-west of village, the slates are rather arenaceous, dip 30° east-by-north, and continue at low angles. Near the top of the pass a long line of pits runs southwards, which were formerly opened for extracting lead ore. The sulphide occurs in minute granular form, in a hard band of quartzite (calcareous), very similar to that at Jungumrajpilly, but quite a different band. This is intersected by a few quartz veins and many ferruginous earthy bands in which the lead sometimes occurs, though apparently more commonly in the body of the quartzite itself near the quartz veins. It has been well extracted, for I was only able to obtain one or two small pieces of ore. The quartzite band dips generally west-by-south at low angles, and the pits seem to be chiefly in an earthy and sometimes brecciated portion of it, next the overlying slates, and I think also next those which underlie, giving the appearance almost of two lodes of ore, one at each side of the band. No traces of

* Evidently a recent deposit.

copper were seen. Iron abounds in a hard ferruginous conglomerate, and also in an impure clay-iron-stone occurring in bands in the quartzite. The line of pits extends about a mile and more to the south, when they cease, and the band of quartzite appears to die away, or does not appear on the surface.

"East of Jungumrajpilly, at a short distance from the village, is a broad band of hard calcareous quartzites, with numerous veins of quartz, chiefly in north-north-east lines. In the quartz are abundant traces of copper. This band strikes north-by-west, dipping east-by-north at 30.° To this succeed bluish grey slates, with the same dip at lower angles. The quartz veins do not pass into these. Again, taking the band of calcareous quartzites east of village and tracing it southwards, there are two bands with a narrow belt of slates between, traceable for about two miles and a half. Traces of copper in the north-north-east quartz veins are tolerably abundant; also copper pyrites and traces of green carbonate. The continuity of the band is broken by cross-faults; first, about a mile from Jungumrajpilly, where it seems to have had a local shift to the east; and, again, about a quarter of a mile further where it seems thrown back again. The general dip is east-by-north at about 25°; but the westerly band is generally at a lower angle, and rolling, even dipping 5° west in one or two places. At the southern end the band is ferruginous. About west-by-north of Raiculcoonta it ceases."

Further west on the flanks of this range, opposite Wonypenta, and at the entrance of the Ghingroy Convoy, there are rolling beds of calcareous slate and silicious limestone, having a general dip eastwards, which have been opened up by long galleries or gullies. These excavations are made across the strike, and nearly in the east-north-east line of jointing, and are evidently old lead mines, though the workings do not seem to have been run in the most favourable line, if the lead occurs here in the same way as it does at and around Jungumrajpilly. No traces of lead were, however, observed here.

Ore good, and apparently in good quantity.

The lead found in the region is a very fine galena; and though we only saw poor specimens of it *in situ* at the time of our visit, still the fragments found lying about among the debris from numerous excavations were very rich in ore; while we have since seen some fine and massive specimens which were reported to have come from the same region. Mr. Wall calls the mineral "silver-lead ore," and according to an analysis made in the Bengal Mint and referred to by him the percentage of silver is very large.

There seems every probability of this being a good mining region,* as far as the traces of ore are concerned: and it is now within much more easy reach of Madras, owing to the opening of the north-western line of railway, than it was when Mr. Wall made his report. There is not a good supply of water, though this could be obviated by damming up some of the stream-valleys which are wet enough between June and October; and thus a good supply, and a fall in case of such a power being wanted, might be ready for working operations in the healthy season. There is not a very large supply of fire-wood, as the forest here has been very recklessly thinned, but sufficient might be obtained to give the necessary fuel required in the workings. Mr. Wall's rather favourable accounts of the resources of these mines is certainly now enhanced by freer communication with Madras.

There is a locality of old lead mining in the Palnád. These workings were in the north-eastern extremity of the Waumyconda range, just behind and above the village of Karampudi, among pale grey and whitish silicious limestones of the Cumbum slates.

* Some very fine specimens of massive cubical galena were lately shown to me by Colonel A. S. Maberly, R. E., Superintending Engineer of the district, who had got them from his Assistant (Mr. Lewis), who was at the time stationed near Nundiallumpett. I had no opportunity of seeing Mr. Lewis after that, but I understood that he had obtained these fine specimens from the neighbourhood of Jungumrajpilly.

Iron ore.

Iron ore is pretty generally distributed among the different groups of both formations. The two limestone groups of the KARNÚLS are often full of octahedra and cubes of iron pyrites, and the quartzites are frequently ferruginous.

Worked generally in the KADAPAHS.

The ore is, however, always worked in the KADAPAH series, where it occurs in layers among the beds, or in veins, strings and nests.

Gunnygull ridge.

The finest occurrence is in the Gunnygull hill ridge, south of Kurnool, which is seamed with great veins of very pure specular iron ore. These occur in the east-west runs of fault-rock on the northern slopes of this faulted ridge: and very much crushed and altered quartzite strata adjacent to the fault-rock are highly charged with the ore. A great cone-like mass of almost pure specular iron ore rises out of the base of the northern slopes; but it is impossible to say how it occurs here, the slope of the hill being so completely covered by debris. The fault-rock all over Gunnygull hill, occurring as it does in several dykes, is generally seamed with strings and irregular masses of specular iron ore, the red hæmatite variety, but micaceous, granular, more massive or botryoidal.

South-east of Ramulkota, on this northern flank, there is a low and parallel ridge made up of altered quartzites which are highly impregnated and stringed with specular iron ore. In fact, this ridge is a perfect mine of iron. The ferruginous beds of quartzite are dipping northwards at high angles. This system of fault-rock dykes runs out westwards past Yeldoorly; and near a small tank between Ramulkota and Yeldoorly, a hill on its south side is largely made up of massive specular iron ore, especially the upper half of it.

The great drawback to the evident richness of this iron-field is the scarcity of fuel, of which there can only be a small supply from the low and thin jungle in the hilly regions to the southwards. The opening

of the Kurnool Canal will, however, give a cheap means of transport if there be eventually any demand for this ore.

Iron-smelting at Ramulkota.

There is one furnace at Ramulkota where iron ore is smelted and afterwards purified. The ore is a massive roughly granular specular iron, coarsely crystallized and very brilliant on a broken surface. It is of a blackish grey color. It is brought from the adjacent Gunnygull hill. Iron is smelted once in a month, during 24 hours. The furnace is charged seven times during this day and night; when seven lumps of smelted metal are obtained. The furnace is charged first (a fire being at the bottom) with powdered charcoal. Two large baskets (6 or 7 large Madras measures) of charcoal are thrown on the fire; then a small basket of pounded ore (74 seers) and 6 small baskets of charcoal, that is, about a handful of iron and a handful of charcoal alternately, at about an interval of a minute. Nothing else is put in the furnace. The bellows are kept at work for about two or three hours. Then the soft mass of metal is raked out; beaten for a short time with heavy hammers until it assumes the rounded wedge-shaped form usually given to the lump of iron at native furnaces, a deep cut being made in the mass. This lump of metal is about three quarters of the weight of pounded ore placed in the furnace; and it is worth three rupees. Afterwards it is reduced to bars of workable iron, by being heated four times in the forge and beaten between each heating. The furnace is a small dome-shaped edifice, almost exactly like the furnaces of the Salem district, both in shape and size.

Other regions.

There are numerous localities all down the western edge of the field from whence iron ore is brought down into the country below the scarps. In general the ore is some variety of hæmatite. On the eastern side of the Khoond-air valley, which is an iron smelting region, the form of ore worked by the people is a massive shaly iron sandstone, mainly made up of peroxide, which

in weathered surfaces is of a brownish red color with a red streak; and when freshly broken is of a tolerably brilliant metallic grey color. This variety is from thin intercalated bands or seams among the ferruginous quartzites in the hills east of Roodrar, which village is the centre of this iron smelting area. At the time of our visit to this village there were four furnaces at work. These are after the usual model in Southern India, as illustrated in our Report on the Salem district.* We were informed that 12 double-handsful of the pounded ore were placed at a time in the furnace; that the result of one furnace is a split-block of 24 seers (a seer being reputed to be Rs. 20 in weight), which split-mass is afterwards forged or beaten four times until a mass of iron is produced of 18 seers weight which is worth Rs. 1½. Considering the high price of labor and food latterly prevalent in this part of the Kurnool district, the people said that this price of a forged block is not high. In many of the villages about here the iron is forged as well as reduced. The native product is largely used for plough-shares and other agricultural implements; but it is not suitable for tires of wheels; English iron being brought up from Madras for this purpose.

The band of ferruginous quartzites shows all along the western flanks of the Nullamullays, from some distance north of Nundiallumpett up to opposite Nundial. The principal iron villages are Bachapilly, Roodrar, with adjacent hamlets, Serinapoor, Kuddamal-calwa, and Galchinpollam. These seem to have furnaces always at work; other villages only work at intervals, or have given up smelting altogether. The ore used at Bachapilly is brought in from the valley behind the outer line of hills. Iron making at Roodrar and the neighbourhood is referred to in an interesting paper by Mr. P. W. Wall, in the Madras Journal of Literature and Science:† and again in Dr. E. Balfour's Cyclopœdia of India.

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* Mem. Geological Survey of India, Vol. IV, part 2.

† Vol. XX, New Series, p. 299, et. seq. 1869.

Mr. C. Æ. Oldham's notes.

"Iron is found abundantly and worked in many places in that portion of the Cuddapah district comprised within Sheet 77. Of these a few may be particularized.

"At Yerragoontla Cotta in the Chittavail (or Rajampett) taluq several furnaces are worked. The ore here used is brought from the eastern slopes of the hills west of Yerragoontla Cotta and is a rich (generally arenaceous) iron stone. This they break small, sometimes mixing with it pieces of a softer more laterite-like ore, and smelt with charcoal in earthen furnaces of the ordinary form supplying the blast through earthenware tuyeres, from bellows generally of goat-skin. They use no flux.

"The charcoal is burned in the jungles adjoining the village on the west, which is in places very dense, and though generally small, in some of the valleys contains some tolerable timber trees. These, however, as far as I could ascertain, are rapidly disappearing; indeed the jungle generally must be thinning in this neighbourhood.

"Near Chintulcherroo (about eight miles north of Dhoor) at a small village named Colapettah (not marked on the Atlas map), iron-working is carried on to some extent. I noticed here ten furnaces at work smelting. The ore used here is a red hæmatite, somewhat silicious, which is collected on, and brought from, the range of hills east of Chintulcherroo, and is tolerably rich; the furnaces are of earth or mud, with earthenware funnel and cap on top, and tuyeres of earthen-ware. Two bellows of goat or calf-skin are used, and keep up a very constant blast. The furnaces are charged three times a day when in full work with a basket-full (three to four maunds) of crushed ore, no flux being used. Charcoal is the fuel used, which is supplied occasionally as required, from above, under the earth-ware cap.

"The yield from each charge is a disc of iron of about one maund in weight, which is split in the usual manner into two pieces, each yielding material for two hatchets or kodalies. There were at the time when I was there two or three other furnaces at work, forging this

iron into hatchets, plough-shares, &c.; five or sometimes six men working at each forge-fire. One generally holding the iron while being hammered, four working the hammers, and sometimes a sixth attending to the fire, supplying fuel, &c. The hammer-men took their turn at the bellows, when not hammering. The iron seemed good, and they apparently worked out the ore pretty well, as the slag seemed not to contain much iron. The ore stretches southwards in a band or bands, for there are two or three, in the same small range of hills; and it is also smelted to a small extent at Neelapoor north-east of Dhoor.

"On the west of the Ghats, in the Rachootee and the Cullcudda taluqs near Mudcherroo, Nerrabyle (Nerrabylegudda of the map), and Chintacoonta the manufacture is also carried on, though not to any very great extent. The ore is brought down from the hills on the east by bullocks and coolies, but chiefly on the former, by the Cutparaty pass and the Chintacoonta Cunnama (or ghat); the ore is precisely similar to and in all probability identical with that used at Yerragoontla Cotta, which, as above mentioned, is brought from the eastern slopes of these same hills, from bands which I suppose to be the same occurring there at a lower level, owing to their dip. Iron is made locally, and in small quantities in many other places through the district, and in many other villages small forge-furnaces are worked; the want of them is in other places frequently supplied by itinerant blacksmiths, who carry about their bellows, anvil, &c., and set up their little forge wherever employment offers itself."

Building material.

As regards building materials, there is no lack of good and easily wrought stone all over the district; but these can only become of value as they are locally required, or as the means of communication are opened out over the district. The railway has done this as regards the Nerjee limestone; and the canal from above Kurnool down to Cuddapah will be another means of opening up the building resources. As yet, the carriage of the Nerjee stone by rail is very expensive, for it is a most compact and heavy

variety of limestone coming very nearly up to the ordinary specific gravity of gneiss. Water-carriage will of course reduce this cost.

Limestone.

The limestones where they are at hand have been largely used by the people of the country, the larger villages in the Khoond-air valley having their better houses built of well-selected and dressed Nerjee beds; while the wells of the Cuddapah and of this valley are all lined with this stone.*

Serpentine.

There are then the serpentinous varieties of limestone, many of which are excessively ornamental, but which will of course not come into use until a desire for ornamental stone-work is created in the country, and a cheap means of transport ready at hand.

Lime.

Lime is easily procured all over the district, more generally from the kunkur deposits, of which there are many in the alluvial flats and underneath the spreads of cotton soil. The pure and more crystalline grey and pale colored varieties of the different limestones are, however, now coming into use in this way, a resource for lime which has been mainly developed by the railway and canal engineers. At Culloor near Kurnool the pale splintery limestone is largely burnt.

Marbles.

Some of the limestones are very well colored, particularly in the Palnád;† and there are the variously colored breccia beds in the western scarps of *Jummulmudgoos* and the bottom of the slates in the Chey-air field, all of which would give very handsome marbles were such to come into demand.

* It is absolutely necessary to line the wells here, for the most of them are first sunk through the purple Nundial shales, which often in their decomposition completely spoil the water.

† Mr. J. Rhode, the late Inspector-General of Prisons in Madras, who was at the time Judge at Guntoor and took a great interest in the rocks of the Palnád, had small slabs of nearly every variety of these limestones cut and polished, many of which are now n the Madras Central Government Museum and are highly ornamental marbles.

Grits.

A variety of the quartzites in the western scarps between Taykoor and Yeldoorly on the Kurnool Government road is largely worked for grinding-stones. This rock is a coarse, rough-grained felspathic grit, which is not so vitreous as the ordinary quartzites. In many other parts of the country close-grained grits are quarried for the same purpose. The half weathered beds are generally quarried in those parts of the beds which now look like unaltered sandstones.

Slates.

As already related, there is no approach among the clay-slates to the slate of commerce, though thin slates are obtainable, and thinner and better ones might be obtained by quarrying and more skilful splitting than is at present in fashion among the people of the country.

Physical structure of the country more suited for increasing the general welfare than these local economic resources.

Such are the direct economic resources of the country, but they are more adapted for the remuneration of individuals, or small communities of such, than for the benefit of the country at large. The great resources in the districts are the peculiar physical features, which, if they are only taken advantage of in the proper manner, may make Cuddapah and Kurnool much wealthier and more populous regions than they are. The great defect of the whole country is, that it is such a generally dry one; while from our experience of some years' working in it, it seems gradually becoming more arid and desert-like. As with the cessation of mining since the Mogul times, so there has been a gradual falling off of attempts to turn to advantage the physical features of the country (which was apparently a matter of great importance with the Hyderabad rulers) ever since the country was taken in hands by the British Government. There are all round the flanks of the Nullamullays, even in what are now the most deserted jungle tracts, the most massive remains of great tanks, which have been bunded back behind the deep parallel valleys which are generally backed up themselves by ridges;

these only need to be made into bunds by the filling up of the narrow gaps cut by the streams. Cumbum tank is one of these splendid works of the old rulers; doubtless, of course, constructed at an enormous cost of life, labor, and time, such as we with our improved knowledge and experience would and could not require or exact; but there it is, and what would otherwise be a desert below the Cumbum ridge is now more or less of a garden.

Other great and old tanks were, it is said, breached purposely by the people because, as the report is, fever and great sickness began to reign over the irrigated region. But whether this sickness was a result of the new climatal influences under which the villages were brought, and would have lasted always, is a question that cannot be decided now. Even now, since the new canal has been opened at Kurnool, fever and sickness have prevailed to a great extent; and the natives are said to attribute this to the new climatal conditions brought about by opening up ground and pouring water over a hitherto dry country; and had they been able to do as they liked, it is possible the canal works might have gone like some of the larger of the old tanks. But it is not at all clear that the new irrigation works have had anything to do with the sanitary condition of the town, except in cleansing it; the prevalence of fever and other sickness for the last three years is more probably due to the fact of there having been an unhealthy period accompanying one of more or less scarcity prevailing over the whole of these and the adjacent districts. Thus it is possible the breaching of the old tanks may have been carried out at a by-gone period of famine and sickness.

Still, there the fact remains that the country by its contour is admirably cut up and laid out for the development of irrigation works: and these are works which are known to be of the greatest benefit to the country and the people. The canal of the Madras Irrigation and Canal Company is in its entirety a splendidly planned work; and it must

eventually be of great benefit to every one. For years and years the supply of rain has been very small: within the last nine years, the Cumbum tank has never been full; and thus it might be said that there is little use in building tanks if we cannot get the water in a country so well adapted to hold it ready for distribution. A probable cause of this diminution of supply is, that denudation of the forests, or jungle-covered hill country, has been going on from time immemorial in the most reckless way. This ought more particularly to be guarded against in the country under description, for, as may be gathered from our account of the strata constituting those hill ranges, the soil is not a favourable one for forest vegetation.

CHAPTER 3.—CONCLUSION.

Attempt at correlation with other Indian formations.

It now remains to be seen whether it is possible to correlate these Madras rocks with any other series that are known in India; and it is unfortunate that we have only their lithology and order of superposition to fall back upon as yet in this investigation. Nearly all writers on these rocks have tried to clear up this point, and have more or less been led to consider them as related to rocks of nearly lithologically the same kind occurring in Central and Northern India.

By the occurrence of diamond-bearing strata.

The fact of the diamond occurring in certain strata at three different points of the country has been looked upon as a great crucial test; only that too little attention was devoted to the finding out what particular series of rocks contained the diamond beds. This has, however, been cleared up lately; and when it is known that the diamond occurs regularly and always in one set of rocks in each area of a formation, whatever it may be, we are to a certain extent justified in looking on the occurrence of the diamond beds in distant and unconnected series of rocks as a point of resemblance or

relation. For instance, there is a group of rocks *(Rewahs)* occurring in the VINDHYAN formation which is diamond-bearing, and alone diamond bearing, as far as present knowledge goes, of all the groups of the formation; and there is a like group (the *Banaganpilly*) in the KARNÚL formation of Southern India; therefore on this ground alone, it is reasonable to examine if the KARNÚLS are VINDHYANS.

By examination of rock specimens.

Again, on reading descriptions and examining collections of the VINDHYAN rocks, it is found that the KARNÚLS bear a strong general resemblance to them, though, indeed, in some respects the KADAPAHS do likewise, until all the groups are examined in detail and then the resemblance falls to the ground.

By relative age.

The age, too, of the KARNÚL and KADAPAH rocks must also be taken into account in trying to correlate them with other rocks, their altered condition, and the fact of their being overlaid by fossiliferous rocks of the *Rajmahals*, necessitates our looking for ancient congeners among other series of like rocks, and here we are brought to look again at the VINDHYANS and their associates.

Compared with VINDHYANS.

The VINDHYANS and their associates have been reported on and largely worked out by Dr. Oldham and other members of the Geological Survey of India; and on comparing specimens of Madras rocks with others of theirs, and looking at the stratigraphy of these formations, the following resemblances are evident.

First, with regard to the KARNÚLS as compared with the typical Upper VINDHYANS as seen in the Rewah country: there is no particular resemblance lithologically except that in both cases the rocks are quartzites or sandstones, shales, and limestones. The sandstones and shales are strongest in the Rewah country; the limestones and shales are strongest in the Kurnool and Cuddapah area. There are consequently none of those grand scarps of sandstones so characteristic

of the Vindhyan range of mountains to be seen among the KARNÚL rocks. Indeed in physical features perhaps the bottom beds of the lower group of the KADAPAHS bear the strongest resemblance to the *Kymores* of the VINDHYANS.

The order of succession of the groups of strata are somewhat different in the classifications of the two formations under comparison. In the KARNÚLS, the diamond-bearing series, or *Banaganpilly* quartzites, is always at the bottom; whereas the group of the VINDHYANS containing the diamond beds is a well-marked middle group. The classifications are as follows in descending order:—

UPPER VINDHYANS.	*Bundairs* ...	... Sandstone, shales, and limestones.
	Rewahs ...	... Sandstones, shales. (Diamond beds).
	Kymores ...	... Sandstones.
KARNÚLS.	*Khoond-airs* ...	... Shales and limestones.
	Paneums ...	... Quartzites (sandstones, &c.).
	Jummulmudgoos	... Shales and limestones.
	Banaganpillys ...	... Quartzites (sandstones and shales) (Diamond Beds).

This difference in the order of the strata does not, however, after all, much affect the question, as it can hardly be expected that the same groups of rocks should always be lithologically the same in different parts of the country, or always associated with like subjacent beds. The *Kymores*—supposing that the KARNÚLS are Upper VINDHYANS—may not be represented in the Cuddapah area.

The main feature of resemblance between the rocks of the Rewah country and those of Madras is, that there is a group of sandstones in each which is alone characterised in each formation by the presence of diamond-bearing beds, though it now turns out that diamonds were

worked for, and found, in quartzites of the Hyderabad territory which appear to be KADAPAHS.

Compared with VINDHYANS on the Mahanuddi.

In 1867, Mr. H. B. Medlicott made a run over certain rocks on the Mahanuddi, which he considers as Lower VINDHYANS. Some of these are like the KARNÚL rocks, while others are like the KADAPAHS. They consist of a set of limestones, slaty-shales, and quartzites, with porcellanic trappoid beds.

The slaty-shales are very like rocks of the same kind among the Cumbums of the KADAPAH formation, which occur to the east of Mookundoo hill near Nundiallumpett, on the western flanks of the Nullamullays. The dark grey (weathering lighter), argillaceous limestone is remarkably like the flaggy limestones of the Koilkoontlas in the KARNÚL ROCKS.

The compact purple and greenish grey banded limestones may be either Nerjee limestone of the *Jummulmudgoos* (KARNÚL F.), or Vaimpully limestone of the KADAPAHS; it is more like the rock of some of the Nerjee beds.

For my own part I should certainly say that these rocks of the Mahanuddi are KARNÚL and KADAPAH rocks; and they are by their lithology preferably of the KADAPAH formation.

Compared with VINDHYANS in the Nagpur country.

Again, Mr. W. T. Blanford has been working at rocks in the neighbourhood of Nagpur, about Chanda and the Pemgunga river. Looking at the specimens of these rocks collected by him, their resemblance to beds of the KARNÚL and KADAPAH formations is very strong. Mr. Blanford considers them as Upper VINDHYANS. They are shales, limestones, and quartzites. The shales are soft, red-purple, argillo-calcareous rocks. They are, in fact, Nundial shales of the *Khoond-airs.* There is a specimen of argillaceous limestone from bands occurring in these 'Pem shales,' exactly like the same bands in our Nundials.

The dark-grey argillaceous limestone might be a specimen from the Koilkoontlas, while the very fine light-colored silicious limestone of Chota Arti is more like a variety of the Nerjee beds of the *Jummulmudgoos*. The latter might be Vaimpully rock; but it is more like the same colored limestone between Kurnool town and the neighbouring village of Culloor, a mile or so to the south.

The quartzite-sandstones and grits from this Nagpur country are like our quartzites: only resemblances in these cannot be relied upon with much certainty, as like quartzites are common to both KARNÚL and KADAPAHS. There is one specimen, however, of felspathic grit from Botajere, which is like our felspathic grits, and which seems to occur in the bottom beds of both formations.

Close resemblance to Lower VINDHYANS.

The most marked resemblance, however, between any of the Madras rocks and those of Rewah, Bundelkund, &c., and Gwalior, is to be seen in certain strata of the KADAPAH formation and others of the Lower VINDHYANS, or of the still lower series at Gwalior.

In the Lower VINDHYANS of the Sone valley there is a tolerable resemblance to certain groups in the KADAPAHS, except that there is no such prevalence of slates and clay-slates on the Sone. Mr. Medlicott's 'coralloid limestone' is like the 'corrugated beds' in the Vaimpully limestones, or the bands occurring in the Tadapurtee slates. His series of silicio-felspathic rocks resembles those in the same sub-group, only that the first are in some cases most 'ashy'-looking in their contained, and evidently travelled, particles of foreign mineral. A specimen of columnar jointed, lightly speckled, trappoid rock bears a resemblance to the more compact spotted shales or 'ashes' in the Tadapurtee slates. Mr. Medlicott had no cases of contemporaneous traps among these rocks, so did not feel justified in calling such ashy-looking beds by any other more significant name than 'trappoid.' In the Cuddapah field there are

overwhelming evidences of contemporaneous trap flows; but the silicio-felspathic rocks are not nearly so clear as to their structure or origin.

Still closer resemblance to the *Gwaliors*.

Again, Mr. Charles A. Hacket, who carried on the working out of the VINDHYANS towards Gwalior, found that they are unconformably overlying a series of rocks which he called the *Gwaliors*. These consist of sandstones, limestones, and shales with flows of contemporaneous trap, all answering very much to the rocks of the Tadapurtee (Poolumpett) sub-group of the KADAPAH formation on the western side of our area. The collection of rock-specimens from the *Gwaliors* can be matched every now and then by specimens from the KADAPAHS in a most remarkable way.

The red and black striped ferruginous jasper shales are common to both; indeed, specimens of these from Gwalior might be taken at once for fragments of jasper beds below the western scarp of the Oopalpad plateau. The brown and black jaspers are also just as like in both formations.

The 'non-descript quasi-felspathic' rocks of the *Gwaliors* are like the spotted and speckled shales of the Penn-air and Chittravutty valley: only that they are harder and more compact, and likewise more crystalline.

The cherty rock with a quasi-organic structure of the *Gwaliors* is, except in the form of its organic-looking contained bodies, like the oolitoid chert of the Vaimpully limestones; and the 'coralloid chert with limestone' is somewhat like our segregated limestones in the same group.

The Par quartzites of Mr. Hacket might be the same as altered beds of the like constitution in the Naggery or Goolcherroo quartzites, though according to position it would answer best to the latter.

The great resemblance, however, between the *Gwaliors* and the KADAPAHS is in the jasper beds, the spotted felspathic rocks, or possible 'ash beds,' and the presence of contemporaneous traps among these.

Conclusions.

Taking then into consideration such poor evidences as the resemblances just described allow of, the following suggestions as to the correlation of the Madras rocks with those of Northern and Central India are put forward :—

The KARNÚLS appear to be Upper VINDHYANS.

There is such a thorough unconformity between the former and the KADAPAH formation, a form of stratigraphic break, which does not, as far as is known, exist between the upper and lower divisions of the VINDHYANS, that we are necessitated to look for representatives of the KADAPAHS among the *Gwaliors* or other like formations which may be overlaid as unconformably by the VINDHYANS.

On this view, the *Chey-air beds* of the KADAPAHS appear to answer best to the *Gwaliors*.

At best, however, comparisons which are mainly dependent on lithological resemblances are as yet comparatively useless in the consideration of these Indian rocks. Even now, our colleagues in the Bengal Presidency are finding fresh fields and series which are lithologically like the KADAPAHS; while there is still great room for admitting further groups into comparison with these, for as yet the *Chey-air beds*, which are supposably like the *Gwaliors*, are only one group out of the four of this formation which are all separated by unconformity and overlap.

The further investigation of the relations of these Madras rocks to those of other provinces must then be left until the intermediate country between them is gradually worked out, when it may happen that the rocks of the north shall be almost brought into close proximity with those of the south, and closer and more satisfactory correlations made than those meagre ones which are attempted now.

APPENDIX.

Mr. R. B. Foote's Notes on the Geology of the Country between the towns of Juggiapett and Bellamkonta in the Kistnah District.

The tract of land lying between the two towns above named is one of very considerable geological interest, including, as it does, the extreme north-east angle of the great area occupied by the KADAPAH and KARNÚL rock series. The central part of this tract occupies the peninsula formed by the Kistnah river (which makes a sharp bend to the north-north-east, and then turns with equal suddenness to the south) just before it finally emerges into the plains a little above the head of its delta. For convenience and brevity I shall speak of this as the Chintapilly peninsula.

Two lines of rocky hills run with a few breaks through the entire length of this area, their courses being very nearly parallel in a direction from north-north-east to south-south-west. Besides these two lines of hills there are numerous outlying hills arranged in a position somewhat parallel to those ridges.

Bottom rocks: Gneiss: Older metamorphic series.

The bottom-rock occurring throughout this area is a granitoid, or syenitoid, gneiss, of the 'blotchy' variety, highly metamorphic and generally porphyritic in structure with very great predominance of felspar and quartz. The signs of bedding are rarely to be found.

Trap dykes.

This gneiss is traversed in various directions by dykes of greenstone, which form in many cases strongly marked ridges, having been much less affected by atmospheric erosion than the coarsely crystalline rocks of the metamorphic series. The great majority of these dykes belong to one or other of

two sets, the one striking from north to south with a little variation on either side, the other set, on the contrary, striking west-north-west to east-south-east.

The dykes consist of a coarse greenstone; and in several of those belonging to the north and south set a well marked porphyritic structure was observed, numerous crystals of pale bluish, or yellowish green, felspar being included. In many dykes thin films of apple-green pistacite occur, lining the planes of jointing. Scattered over the surface of the ground to the north of the traveller's bungalow at Sheer Mahommedpett on the Masulipatam and Secunderabad road is a large quantity of extremely rich red hæmatite occurring in slightly rounded water-worn lumps from the size of a pea upwards to lumps weighing several pounds. The quantity increases northward towards the Condalama Trigonometrical Station Hill; where, among the singular net-work of trap dykes seaming the face of the country, the quantity of this iron-ore is extremely large. It presents every appearance of having been derived from some distant source, of which not the slightest indication was observed. This ore is carried by the Brinjarees to several villages in the Nizam's territories west of Warrapilly (Wojerabad) to be mixed with the greatly inferior ore locally found there.

Newer metamorphic series.

Lying on the gneissic rocks is a series of rocks consisting of quartzites, slates, shales, and limestones, the relations of which are (in some parts of this area) far from clear and obvious.

Nature of boundaries.

Along the northern edge of the angle which terminates the great area of these younger metamorphic rocks they rest upon the older gneiss quite undisturbedly, but on the eastern edge of the angle the boundary is in parts a faulted one. Between the southern part of the two ridges of hills before described a remarkable area of the gneissic rocks appears within the general boundary of the younger metamorphics, brought in by a series of nearly parallel

faults. Another small area of gneiss appears about five miles north-west of Chintapilly immediately below the lofty ridge running from the Pulichinta hill northwards. This area is also brought in by faults.

Outliers.

Of outliers of the younger metamorphic rocks only three occur—the Congramulla four miles and a half east-by-south of Juggiapett, and the broad low dome-shaped hill one mile and a half south-west-by-west of Achammapeta; the third outlier is a very small one, only a few acres in extent, lying immediately north of the extreme north end of the Achammapeta hill.

To what division referable.

Some obscurity exists as to the geological horizon to which these younger metamorphic rocks should be referred; those forming the base of the series at Juggiapett being apparently a continuation of the quartzites and slates occurring in the Biravallipaya dome, south of Bellamkonta, which latter rocks there seems every reason to consider as belonging to the KADAPAH formation, the lowest division of this younger metamorphic series, as shown to the west of Nakarikallu.

Position of Palnád limestone.

The fine grey and variegated limestones of the neighbourhood of Juggiapett, which to all appearance rest conformably on the Juggiapett quartzite and intermediate slate bed, are considered as an extension of similar limestones occurring north and north-west of Nakarikallu which Mr. King regarded as equivalents of the *Jummulmudgoo* limestones, a member of the KARNÚL formation, which in the Kurnool district lies unconformably on the KADAPAH formation.

Should these limestones prove to be *Jummulmudgoo*, I cannot think but that the northward extension of the Nakarikallu set of rocks of the KADAPAH series must stop short with the Biravallipaya dome. I certainly could not trace any signs of unconformability between the Palnád limestone series and the Juggiapett quartzites and slates; and, if these are

truly conformable with the limestones in question, the two must stand in the same relation as the *Jummulmudgoo* and *Banaganpilly* beds of the KARNÚL series. The Juggiapett quartzite would then represent the *Banaganpilly* group of the Kurnool district, with which it agrees in the fact of its containing diamonds.

The sequence of formations occurring in the neighbourhood of Juggiapett may be represented in the following order of superposition, descending :—

7. Quartzite (*No.* 7) capping the Pulichinta Trigonometrical Station Hill.

6. Chocolate slates *(g.)*

5. Jatapalle quartzite bed (*No.* 6).

4. Ginjupalli series, gritty quartzites (*Nos.* 2, 3, 4, 5), and slates or shales *(b, c, d, e, f)*.

3. Palnád limestones l^1 *(Jummulmudgoos?)*

2. Juggiapett shales or slates *(a.)*

1. Juggiapett quartzite (*No.* 1), including a thin bed of dark-colored shales (or slates) near its base.

I make this division with considerable doubt, as the sections are not as clear as might be wished, while the presence of a considerable number of faults and the entire absence of any fossil remains render it impossible to feel much certainty in assigning the different detached patches of quartzite, limestone or slate to distinct horizons. A large proportion of the slate areas is obscured by a thick layer of vein-quartz debris.

The great extent and thickness of the jungle contributed greatly to the difficulty experienced in this matter; while the insufficiency of detail in the map, with occasional faultiness, in no way tended to the mitigation of evils. In illustration of the structure of the area now under consideration, I have constructed seven sections, which will assist in explaining the rather complicated relations between the different parts

of the series as met with in many places. In parts these sections are ideal, the nature of the ground and the total absence of fossils or other indications often rendering it impossible to make out the true position of the formations, or to identify with any certainty beds of similar lithological characters when met with in different localities. The sections in question are the following (Plate VIII):—

No. I.—From Moogetalah to the Trigonometrical Station of Oostapully hill, a distance of nine and one-third miles.

No. II.—A section across the 'Chintapilly peninsula,' extended beyond the Kistnah river on both sides and passing through the villages of Nemalipuram to the west and Goodimetta to the east, ten and half miles.

No. III.—A section diagonally across the 'peninsula,' extending over the villages of Nemalipuram and Coutranepully, a distance of eleven miles.

No. IV.—A section running west-by-north to east-by-south through the villages of Moogetalah* and Kunlamuddi, a distance of six miles.

No. V.—A section five miles in length running parallel with No. IV, a mile to the north, and half a mile north of Raveralah.

No. VI.—A section running south-east from the Kistnah river at Uddaloor (across the village of Venkatayapalem) for a distance of nine miles.

No. VII.—A section running south-east-by-east through the village of Manesultanupalem to Perekipadu.

The sections are constructed on a horizontal scale of one inch to the mile. Vertically the heights are arbitrary and exaggerated, no data existing for a true scale.

A description of the several sections will best explain the nature of the rocks exposed in them.

* This village, named Moogetalah in the map, is locally called Mootiala or Muktiala. It is the residence of Rajah Vassareddy, a wealthy and respected zemindar who owns much land in the Nandiganah Taluq. The village stands on British territory.

Description of Section No. I.

From Moogetalah to the Oostapully Hill Trigonometrical Station.

In the continuous part of this section, *i. e.*, the central and western, the lowest formation met with is the great spread of limestone (*l^1* in the section) at and opposite to Moogetalah. This is a grey or grey and white compact flaggy limestone dipping eastward at moderate angles of from 10° to 15° or 25°; a dip of 30° is not commonly met with. A great thickness of this limestone shows at Moogetalah; but this is most probably a deceptive appearance, owing to a number of small faults by which the same beds would be reproduced frequently at the surface. In other places, where a safe estimate of the thickness of the limestone is feasible, 80 to 100 feet would seem to be the utmost thickness assignable to the formation; and elsewhere again it is unquestionably very much thinner than that. I could not positively trace any of the above supposed small faults, but have no doubt whatever of their existence about half a mile east of the Kistnah; the limestone dips under slates (*b*); and at the brow of the first rise a thin bed of quartzite (*No.* 2) appears. This bed is irregularly developed along its strike, thinning and thickening alternately within short distances.

About half a mile south-east of the line of section the slate beds (*b*) underlying the above quartzite are seen in the bed of a nullah to be much folded upon themselves, some of the folds being inverted. In the width of the nullah-bed three folds are distinctly exposed, and other folds are seen to disappear under the loamy banks of the stream. The planes of cleavage of these (at this place pale greenish grey) slates are well seen, and are parallel with the axis of the folds themselves.

Proceeding south-eastward with the section, the quartzite (*No.* 2) is overlaid by another set of slate beds generally of mottled (white and chocolate) or chocolate color (*c*), presenting no features of special interest along this line of country. Resting on the slates (*c*) is another

quartzite bed (*No.* 3) which stretches across the Chintapilly peninsula from Jatapalle to opposite the Vadadry hill pagoda; from its superior hardness it has remained as a capping to a ridge a couple of hundred feet high. This is generally a compact whitish quartzite often much permeated by quartz veins. The rock is often of remarkably waxy lustre, and then extremely hard and slippery. This formation is again followed by slates of grey or chocolate colors *(d)*, overlaid in their turn by a bed (No. 4), which in some parts is decided grit, in others again a true quartzite, the passage between the two being rapid. Where the gritty character obtains the whole surface of the bed is riddled with old diamond-pits. Occasionally the grit passes into a regular pudding-stone of white or grey quartz pebbles included in a silicious matrix. Over some parts of its surface this bed has been much denuded so as to form a mere film often only a few inches thick. This is the case where crossed by the line of section. It is here also of very small thickness, but thickens out again both to the east and west, to a formation of considerable importance.

This diamond bed may be traced right across the Kistnah on either side of the 'peninsula.' It is overlaid by a series of chocolate-colored or mottled slates *(e)* of no great interest or importance; these in their turn are covered by a thin bed (*No.* 5), waxy and quartzitic in texture, which, like bed (*No.* 4), has in places been worked for diamonds. This bed appears again a little to the south, being brought up to the surface by a fault.

Resting on bed (*No.* 5) comes another series of slates *(f)* of mottled chocolate and white, pale chocolate, or drab colors, capped by a quartzite and diamond-grit formation (*No.* 6), forming a long narrow plateau about a mile west of the village of Ballagarige. This plateau appears to form the upper bed of a very flat synclinal fold, so flat as to be barely appreciable in the uppermost beds. The lowest bed of this band is a grey or whitish quartz-veined

quartzite, overlaid by other beds of quartzite of whitish, reddish, or bluish colors. These are followed by grey and whitish gritty beds, the surface of which has been much broken up, apparently in search of diamonds. The total thickness of these beds I estimate as from 80 to 100 feet, and they form the highest of the series as far as exposed along this special line of section.

Continuing south-eastward along the line of section the slate series *(f)* reappears, the slates being here chiefly of dun grey and drab colors. Below these slates are a succession of quartzites (and grits) and slates, agreeing in lithological character and relative order with the beds 5, 4 and 3 of the former and *e, d, c* of the latter in the north-west half of the section. These bands are arranged apparently in a low anticlinal fold; but from the nature of the ground their position is very obscure and a little doubtful. If the anticlinal fold be really the true arrangement of the strata the slates *(e)* must be faulted against the much lower slate bed *(a)*, for the latter is overlaid by a limestone *(l^1)* which I cannot but consider as belonging to the Palnád limestone, both because of its peculiar character and of that of the underlying slate, which is of a dark purple color characteristic of this bed in many other places where no possible doubt can arise as to its real position in the series. Resting on the limestone, which has here a much smaller thickness than at Moogetalah, is a bed of quartzite that must be regarded as a distinct and separate formation or as the quartzite (*No.* 2), the slate bed *(b)* of the other end of the section being nurepresented.

These beds are suddenly cut off by a fault, and abut against a mass of gneiss.

The reappearance of exactly the same beds in the same relative position about half a mile to the south-east would seem to confirm the latter view. They are brought in by another fault. The quartzite bed (*No.* 2) appears on the east side of the Kistnah, forming the bare slope of the Oostapully hill. The limestone has apparently thinned out

before reaching this point, as it is not seen in the sections afforded by the ravines on the hill side in which the slate band *(a)* is exposed. The same limestone *(b)* occurs further north in its normal position, as will be pointed out in the description of Section No. II. Further south the limestone bed thickens out very considerably, but is lost sight of near the end of the Chintapilly ridge, being covered up by a great thickness of massively concretionary kunker and also by a great talus of quartzite debris. The slate bed *(a)* is underlaid by the basement quartzite (*No.* 1) which crops out to form the summit ridge of the Oostapully hill. The surface of this bed, though but very slightly friable, has been broken up considerably by the diamond miners, by whom the talus surrounding the hill has also been searched at a recent period.

The other diamond mines before mentioned appear, from the highly weathered condition of the rubbish heaps, to be of great age. The base of this quartzite formation (*No.* 1), which I propose to designate as the Juggiapett bed (from the fact of the town of Juggiapett standing on its edge), is formed by a coarse brown grit of small thickness, separated from the mass of quartzite by a thin bed of dark grey slates. The grit bed rests on the uneven and eroded surface of the granitoid gneiss. This is well seen about half a mile south of Ramanapetta.

Description of Section No. II.

From Nemalipuram to Goodimetta, 10½ *miles.*

A considerable amount of agreement will be found between this and the foregoing section on examination of the succession of formations exposed along its line.

The direction of the section is from east to west from a point two miles west of Nemalipuram to a point two miles east of Goodimetta, thus cutting across the Chintapilly peninsula nearly at its widest part,

and extending some distance across the Kistnah river on both sides. No difference of importance is to be observed in the successive formations traversed from west to east, from the east edge of the Palnád limestone-spread *(l^1)* till the right bank of the Kistnah is reached, unless it be that the quartzite (*No.* 2) contains a gritty bed near the top which has been broken up in search of diamonds on the flanks of a hill about three quarters of a mile north of the line of section. At a small distance south of the line of section this bed and the following quartzite beds Nos. 3 and 4 thin out rapidly and no longer stand out as ridges; south of the Kistnah, near Kollur, however, they reappear and reassume their ridgy character. On the right bank of the river, between the village of Pulichinta and the base of the high Pulichinta ridge, a limestone *(l^2)* appears among the slates of band *(f)*. The limestone is of a greenish grey, and near its upper surface much intercalated with argillaceous laminæ, which become so numerous that the limestone is lost in slates.

This limestone is not seen north or south of the line of section for any distance owing to surface accumulations. Overlying the limestone comes a thick series of slates, chiefly of chocolate color, separated by a quartzite bed corresponding, if the sequence be a true index of position, with No. 6 of Section I. Regarding this limestone *(l^2)* as a merely local deposit, I have in the section indicated the over and underlying slates by the letters *f* and f^1, and the slates overlying quartzite No. 6 by the letter *h*.

Capping these slates comes the thickest quartzite formation of this region, a formation probably not less than 300 feet thick made up of pale drab, pinkish and whitish beds. This quartzite forms the backbone of the great Pulichinta ridges, and slopes down the entire east flank of the ridge till cut off by a fault by which the slate bed *(f)* is brought up to the surface on the eastern side of the valley lying between the ridge and the Cuchillabode, a high and peaked hill about a mile to the east of the ridge. About half a mile south of the point at which the line of

section crosses the line of fault by which the great quartzite bed is cut off, the fault line has trended away somewhat to the east, and the quartzite bed is seen to rise into a ridge opposing the main ridge and thus forming a deep and important synclinal fold which continues fully three miles southward, when it is terminated by an elliptical curve of the strata rising up to the south, thus closing up the fold, and forming a huge trough which may be entered by a deeply-cut gap lying due west of the village of Chintapilly. Northward of the line of section the fault line continues in the axis of the synclinal fold, but so great an up-throw has taken place on the east side of the fault that the gneissic rocks are brought up to the surface, as shown in Section III. The highest part of the main ridge rises to an elevation of 1,191 feet at the Pulichinta Trigonometrical Station, which stands within the enclosures of an ancient hill fort now in ruins called the Madera Laladurgum. Proceeding with the line of section across the Cuchillabode, beds will be found in position corresponding with *f*, l^2, f^1, *No.* 6, *h* and *No.* 7. But the slates *f*, f^1 and *h* have thinned out greatly. The limestone (l^2), where seen at the south side of the Cuchillabode, is a fine flaggy stone of white or pale bluish grey, but when traced northward changes rapidly into a dark green-grey rock in which the argillaceous greatly exceed the calcareous laminæ. The capping bed (*No.* 7), the highest member of the whole series, is a fine, waxy, yellowish or bluish white quartzite. At the base of the Cuchillabode on its eastern side another fault is met with, but not of great importance in amount of throw, and only of small length; by this fault the greyish white, and locally very gritty, quartzite bed (*No.* 5) is brought up against the slates (*f*). About a quarter of a mile further east this gritty diamond bed is covered by the slates (*f*). The limestone bed (l^2) and slates (f^1) do not appear at this spot (possibly they are only hidden by debris), though they both appear in force half a mile or a mile to the north-by-west. Succeeding these beds comes a grit and quartzite formation agreeing in position with No. 6, and agreeing closely in lithological characters with the grits and quartzites of the Ballagarige

plateau, but with several small beds of slate intercalated between the several silicious beds.

To the northward these slates thin out rapidly, but to the south and south-west they swell out and become important beds. The gritty quartzites form, where crossed by the section, a well marked ridge which slopes down slowly towards the north till it reaches the Taduvayi nullah. In this position the entire surface of the gritty parts is honeycombed with innumerable old diamond pits. Following the section further eastward an undulating plain covered with jungle stretches away for upwards of two miles. Nothing is seen here but pale chocolate, drab, buff and white slates, much obscured by quartz-debris derived from the very numerous little veins and films of quartz which abound in the slates. Some of these slates certainly represent the bed *h*.

As the bank of the Kistnah is approached a fault brings in the slate beds *(a)*, the limestones *(l^1)* and quartzite *(No.* 2), in the very same way as in Section I: indeed the two sections cross each other at this spot.

The small patch of these three beds which appears on the east side of the faulted intrusion of gneiss in the bank of the Kistnah (visible only when the water is low) is not seen along the line of Section No. II; but on the east (here the left) bank of the Kistnah the village of Goodimetta stands on the slate bed *a;* while the Juggiapett bed of quartzite *No.* 1 forms a ridge running from the summit of Oostapully hill for several miles northward to Cautranepully, where the beds trend eastward and southward to form the two bays north-west of Peddavaram.

Following the section eastward from Goodimetta the granitoid gneiss is exposed for about a mile, and then another outcrop of bed *No.* 1 follows. This time the quartzite dips eastward, and is suddenly cut off by a line of fault by which the gneiss is again brought to the surface or rather the quartzite dropped down. To the southward the quartzites run down to the Oostapully hill, where they trend round eastward and finally northward; northward of the section the beds trend north-north-

east, and the fault line last referred to runs north 5° west, so their course is soon cut off, and they terminate in an acute angle about two miles south of Peddavaram. There has evidently been an anticlinal fold with elliptical ends here extending from the Oostapully to the Peddavaram hill, the ridge of which has been entirely denuded away.

Description of Section No. III.

From Nemalipuram to Cautranepully, 11 *miles.*

The beds cut across by this line of section are the same, till the Pulichinta ridge is crossed, as those exposed in Section II. East of the fault, however, by which the quartzite bed (*No.* 7) of the ridge is so suddenly cut off we come upon the gneissic rocks, showing that a very great upheaval has taken place here and the entire series of beds (probably not less than 2,000 feet thick) cut away by denudation. The gneiss-spread thus exposed is bounded by four lines of fault, forming a four-sided figure having its longer diameter from north to south, a distance of about one and half miles. The northern end of the figure is rather narrower than the southern, which cuts across the foot of the Cuchillabode hill; all the boundaries are covered up either by talus or forest, which is here very thick. East of this gneiss-area the series of beds reappears, and agrees on the whole with the succession seen in the corresponding part of Section II, the principal point of difference being that the slate band *(f)* is replaced by a great thickness of limestone of whitish grey, banded grey and white, or grey limestone of great beauty and purity. The quartzite and diamond-grit series *(No.* 6*)* here shows a slate bed intercalated so as to divide it into two divisions, both of which have been worked for diamonds. Other small local slate beds split up the series still more, but further south they seem to disappear. To the north these diamond beds can be traced up to the Taduvayi nullah, but there disappear, probably cut off by a continuation eastward of the fault from the north boundary of the upheaved gneiss area.

Proceeding along the line of section there appear good reasons to believe in the existence of another fault crossing the Chintapilly peninsula from a point about a mile south of Jatapalle to near the embouchure of the Taduvayi nullah into the Kistnah; by this fault slates and thin beds of quartzite appear on the north-east side of the nullah; which beds are probably representative of beds *(e)* and (*No.* 5) greatly thinned out. Beds *(f)* and (*No.* 6) where the Ballagarige ridge plateau is crossed agree in every respect with the beds described in Section I.

On the eastern slopes of the ridge down to the Kistnah no quartzites are seen among the slates as in Section I; they have probably thinned out completely. A little south of the village of Ballagarige white and greyish white compact limestone appears, and forms the rocky bank of the river on both sides. At the village of Cautranepully the limestone is much mixed near its base with argillaceous laminæ. The underlying slates *(a)* and quartzite (*No.* 1) offer no local specialities. The Peddavaram hills are capped by the bed (*No.* 1), which here shows the small included dark grey slate beds and the gritty basement before referred to.

Description of Section No. IV.

From west-by-north to east-by-south across Kuntamuddi village, 6 miles.

The grey limestones seen at Moogetalah and Madipadu are overlaid by the chocolate, drab, and greenish grey slates *(b)* abutting against the slates *(a)* where brought up by a fault; this break is covered up by thick black alluvium, but it must lie some distance west of Kuntamuddi village, which stands on a thin spread of the limestones *(l^1)*. By another fault, about half a mile east of the village of Kuntamuddi, the slates *(b)* and *(c)* are brought to the surface and continue into the river. On the east side of the river a quartzite bed, apparently (*No.* 3), shows when the water is low. Over this are slates *(d)* forming the river-end of

the Vadadry Pagoda hill, the southern face and ridge of which are of a quartzite (*No.* 4)—a rather thick bed of whitish waxy quartzite with many laminar patches of red color in its substance; this is suddenly cut off by a fault, by which the limestone (l^1) is brought to the surface on the south side of the Vadadry nullah. A great thickness of slate beds then follows which I believe represents beds *b*, *c*, and *d*. The quartzite band (*No.* 3) seems to be absent, though possibly only masked by debris or jungle. Capping this slate series is a quartzite bed in every way agreeing with the Vadadry Pagoda bed in texture, color, &c. The position of this capping of quartzite is very peculiar, for it slopes down the east side of the great hill east of Vadadry at an angle ranging from 20° to 25°, though as much as 55° is the dip of the same set of beds a few hundred yards to the north. Near the base of the slope a fault occurs, by which the limestones (l^1) are brought to the surface and abut against the quartzite, the dips of the two being opposite as if forming a synclinal fold. In plan this hill shows a very singular collocation of beds, apparently due to the meeting of three faults,—the fault above referred to as running along the south side of the Vadadry Pagoda hill and extending from the Kistnah to a point at the north foot of this hill,* secondly, a north-south line of fault just mentioned as running along the base of the east slope of the hill, and, thirdly, another fault running from the southern end of the second (north-south) fault in a direction nearly parallel with the first down to the Kistnah. I could not, after a most careful search, discover any signs of continuation of the lines of fracture of these three faults beyond their points of junction. Where the different slate rocks abut along the faults cannot be detected on the surface, nor was any section found showing the amount of dislocation.

* This hill, though fully 600 feet high, is not shown on the map, but instead of it a tank is indicated which has no existence; *per contra* on the west side of the Kistnah west of Ginjapalli and south of Kuntamuddi a large hill is shown in the map, where in reality a good sized tank exists.

At the points at which the line of section crosses the beds *a* and No. 1, at the eastern extremity of the section, these offer no peculiarity; but to both north and south they have been much more contorted, and instead of having a simple westerly dip of from 40° to 45° they are seen (especially in the latter case, in the opening through which the Streerunganaikdroog nullah flows) for a slight distance vertical and actually thrust over and inverted, but no signs of any fault accompany this inversion, which is distinctly seen in two or three sections made by different nullahs cutting through the boundary ridge. The inversion in the Streerunganaikdroog nullah amounts to as much as 15° to 20° east, the general dip being of from 40° to 45° west.

Description of Section No. V.

Half a mile north of Raveralah, 5 *miles.*

The western part of this section (which runs from west-by-north to east-by-south about a mile to the north of that last described) shows the same beds as the corresponding part of Section IV, namely, the limestone *(l^1)* and the overlying slates *(b)*, which are faulted against an upheaved part of the same limestone, overlaid by a slate series representing the beds *(b)*, *(c)*, *(d)* and *(f)*; amongst which occurs a quartzite bed in all probability (*No.* 3), (*No.* 2) being only a local and extremely thin bed of quartzite hardly to be noticed; (*No.* 4) is a whitish waxy quartzite with rather numerous laminæ and patches of red color interspersed in the mass. This bed occurs as capping to four or five points of a ridge about a mile north-north-east of Vadadry village. The quartzite bed (*No.* 3) seems to have thinned out before reaching the east side of the ridges, at least it is not seen on the nearly bare hill side.

The remaining eastern part of the section shows no peculiarities in the stratigraphical position of the limestone *(l^1)* slates *(a)* and

quartzite (*No.* 1), which are the formations lying between the ridge and the gneiss boundary. One mineral peculiarity of the limestone bed (*l*) deserves notice however, namely, that at the upper part of the bed it has become very argillaceous and ferruginous in composition, and presents the appearance of a calcareous shale mixed with partly laminated partly concretionary clay-iron-stone of dull red, purplish or even bluish color, with a red hæmatitic streak when scratched. These form an irregular capping to the low ridge here formed by the basset-edges of the limestone. In part this peculiar ironstone is certainly a sub-aerial formation resulting from the weathering of the ferruginous shaly limestones. It occurs largely at this part of the limestone area and in several other places under very similar circumstances, but invariably as a cap to this argillaceous limestone. Other localities for its occurrence are:—all about the limestone spreads north and north-east of the Streerunganaikdroog; on the top of the limestone at Cautranepully east of the Kistnah; a little to the west of the road leading from Chintapilly to Madipadu diagonally across the peninsula; again and very largely to the east of Bojanam, on the Kistnah, twelve miles south-west of Chintapilly; and in the corner where the limestone is faulted against the quartzite of the Gudibonda hill.

A similar ironstone formation has been formed by the weathering of the rather shaly upper part of limestone (l^2), about a mile north-north-west of where that limestone is crossed by Section No. III.

Description of Section No. VI.

From the Kistnah across the Venkatayapalem Hill to the Achammapetta Hill, 9 *miles north-west to south-east.*

Proceeding south-eastward from the Kistnah at Uddaloor, a spread of nearly two miles of shaly and thin compact grey limestone is passed over, the beds dipping at a rather low angle at first, then very

gradually increasing their dip till they pass under the slates *(b)*. The limestone is much obscured by cotton soil, so it cannot be decided whether the thickness of the limestone has been here exaggerated by faults repeatedly bringing up the same beds to the surface. From the boundary between the limestones and the slates the ground rises steadily up to the top of the Venkatayapalem hill; and along this rise there appears an unbroken and nearly perfect succession of all the slates and quartzites recognized further to the north. The general lithological features of the different beds are not different from their appearance elsewhere. The limestone *(l^2)* does not here accompany the slates *(f)*; but an extra bed of gritty quartzite occurs in its place marked (5 *a*) in the section. The summit of the hill forms a small but striking plateau surrounded by a small scarp on all sides. It is capped by a dark reddish brown gritty sandstone which has been perfectly honey-combed with diamond pits. This gritty bed represents only the lower part of the great quartzite formation of the Pulichinta ridge, if it be regarded as the real representative of that formation, which seems rather a matter of fancy, for it might with equal propriety be set down as being the upper part of the (No. 6) diamond grit, separated merely by a rather unusual thickness of slates (*vide* Section III). Descending the hill to the east a line of fracture is crossed; and the gneissic rocks are found to abut against the horizontal (or nearly so) beds of slate *(f)*. Near the centre of the valley is the village of Venkatayapalem, after which I propose to call this very singular trough between the two ridges of hills. The upheaval of the gneiss-area of this valley is remarkable for its great length and narrowness, and for the great height to which the intruded gneiss rocks were forced up. There is not the slightest trace of any of the once overlying quartzites, &c., to be seen on the gneiss, which rises in many places into great hummocky hillocks, some of which are not much under 100 feet in height. The southern end of the valley is thickly covered with a coarse shingle, chiefly made

up of quartzite, but mixed also with fragments of hard slate and of gneiss. This has been, near to the now abandoned village of Suravaramkottapeta, turned over for diamonds; a great number of pits and heaps being visible in the jungle. The quantity of this gravel and of talus along the foot of the ridges in other parts of the Venkatayapalem valley is so great that the position of the lines of fault could be only approximately ascertained, but nowhere actually seen.

The Chintapilly ridge where crossed by the section line proves to be a tilted anticlinal fold, the tilting being towards the east, and so great that, while the beds on the west side of the ridge have an easy slope of about 25° to 30°, on the east they are bent round sharply to dip vertically in some places and at extremely high angles elsewhere along the ridge. South of the line of section, about opposite the village of Nindujarla, the east side of the anticlinal appears no longer, owing to the greater amount of denudation; and with the exception of a small fault west of Nindujarla the boundary is formed by a simple basset edge with westerly dip. Crossing the line of fault at foot of the Chintapilly ridge, whereby the gneiss is made to abut against the vertical beds of quartzite, a valley nearly a mile wide is reached, on the east side of which another line of fracture has occurred, and beds of quartzite appear to be dipping under the gneiss. These beds form a broad flat dome rising from a rudely five-sided base. The dip of the quartzites is to a certain extent quaquaversal; but the dome is imperfect, having a slight degree of ellipticity, the major axis of the ellipse making apparently a slight bend to the east; the average dip all round is from 30° to 40°, perhaps a little higher on the west side. The rock is a series of quartzite beds of unascertained thickness; generally waxy in texture and of drab or whitish pink or grey colors. It strongly resembles the quartzite of the ridge just described, and both may with good reason be considered as representing the Juggiapett bed (No. 1).

Description of Section No. VII.

From one mile north-west-by-west of Manesultanupalem to Perekipadu, 6 miles.

This section shows the position of the rocks forming the eastern and western sides of the Venkatayapalem valley in its southern part. At the western extremity of the section the limestone bed *(b)* is represented, but at that exact spot is highly impure and shaly. This limestone abuts against the highly inclined quartzite beds of the Gudibonda ridge which are brought up by a fault. These quartzites are unquestionably the Juggiapett beds (No. 1), forced up into an anticlinal fold, as seen a little distance to the north, though on the line of the section (owing to a slant in the line of the fault) only the eastern slope of the anticlinal has been brought up. At a little distance from the foot of the ridge on the east side a small patch of the limestone *(l^1)* is exposed, abutting on the east against the upheaved gneiss of the Venkatayapalem valley. The slate *(a)* is not seen along the line of section owing to a thick bed of soil and great talus, but further north it is well seen. As the ridge runs north the anticlinal fold rises to a much greater height and is greatly squeezed up; where the ridge reaches its greatest height it is almost inverted near the top; and on its western flanks the entire thickness of the lower limestone series *(l^1)* is exposed, here capped by the iron bed described in Section V.

About a mile south-east-by-east of Manesultanupalem, a fault brings up the upper part of the quartzite No. 1, which is capped by a bed of grey limestone, the slate band *(a)* being absent, or at least only represented by a thin band of shaly limestone. The underlying quartzites are whitish in color and generally waxy in texture.

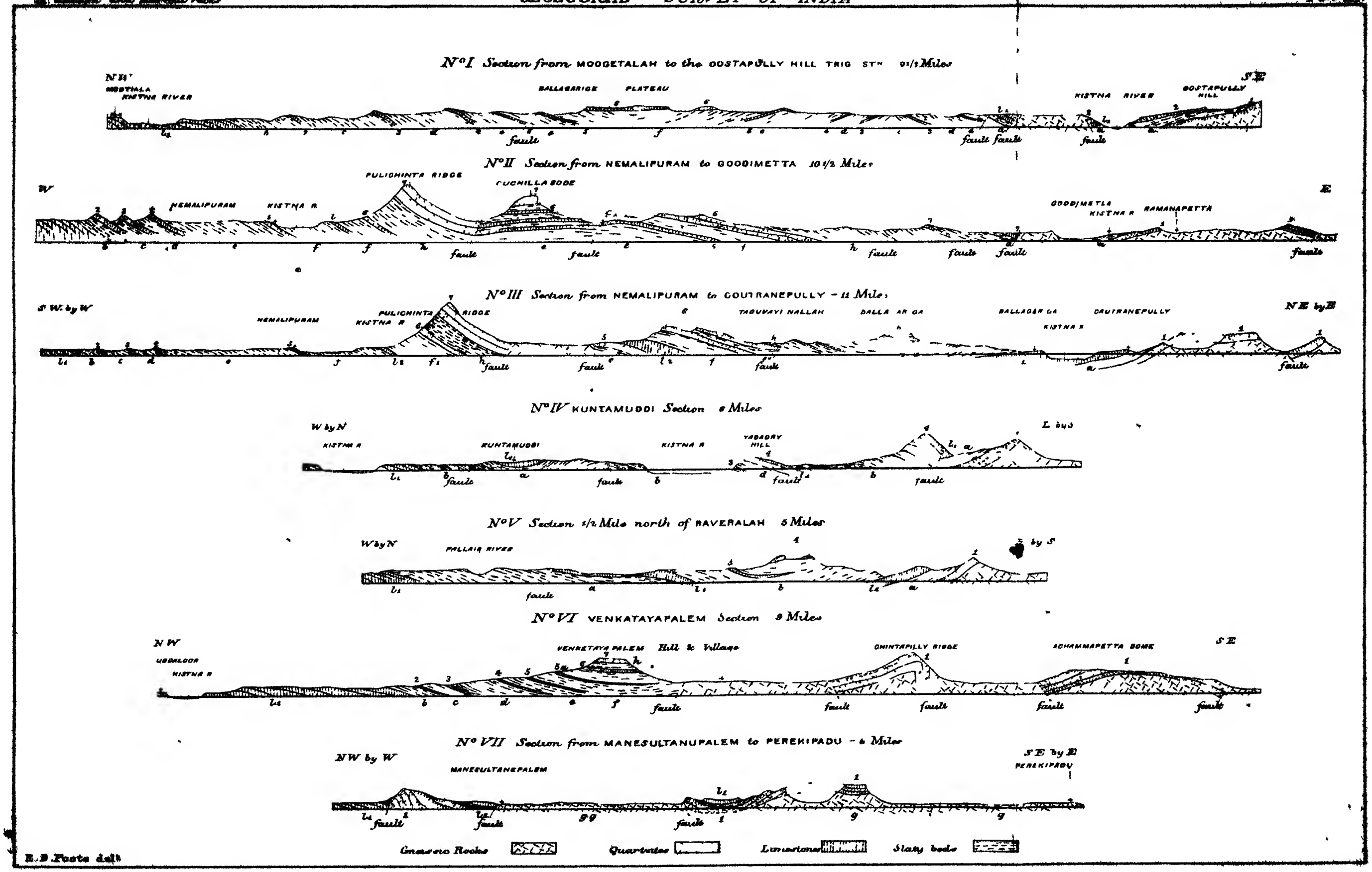
The extension of all the different rocks, described in these seven sections, to the westward in the Nizam's territory on the north side of the Kistnah is extremely simple in geological structure; the only beds represented being the Juggiapett quartzites (No. 1), the slate *(a)*

and the limestone *(b)*; no faults or contortions of these strata are met with anywhere; the boundaries are simply boundaries of erosion. No change of lithological character of importance takes place, but the distinction between the quartzite (No. 1) and the slates *(a)* becomes difficult to carry out, and has, therefore, not been attempted to the westward of the village of Sowtapully. The general dark purplish or brown color of these slates, or rather shales (for no traces of cleavage is seen where the beds are not contorted), is less continuously met with; and paler colors prevail as a rule. Altogether, an area of very considerable disturbance is followed by an area over which the members of the younger metamorphic rocks have been subjected to no contorting action. They dip at angles so gentle that these may well be the original angles of deposition, the scarps and outliers now observable along the north-western margins of the area being merely results of erosion acting strongly on the underlying coarsely crystalline granitoid gneiss.

M. Kadapa and Karnul rocks

GEOLOGICAL SURVEY OF INDIA

Pl. VIII



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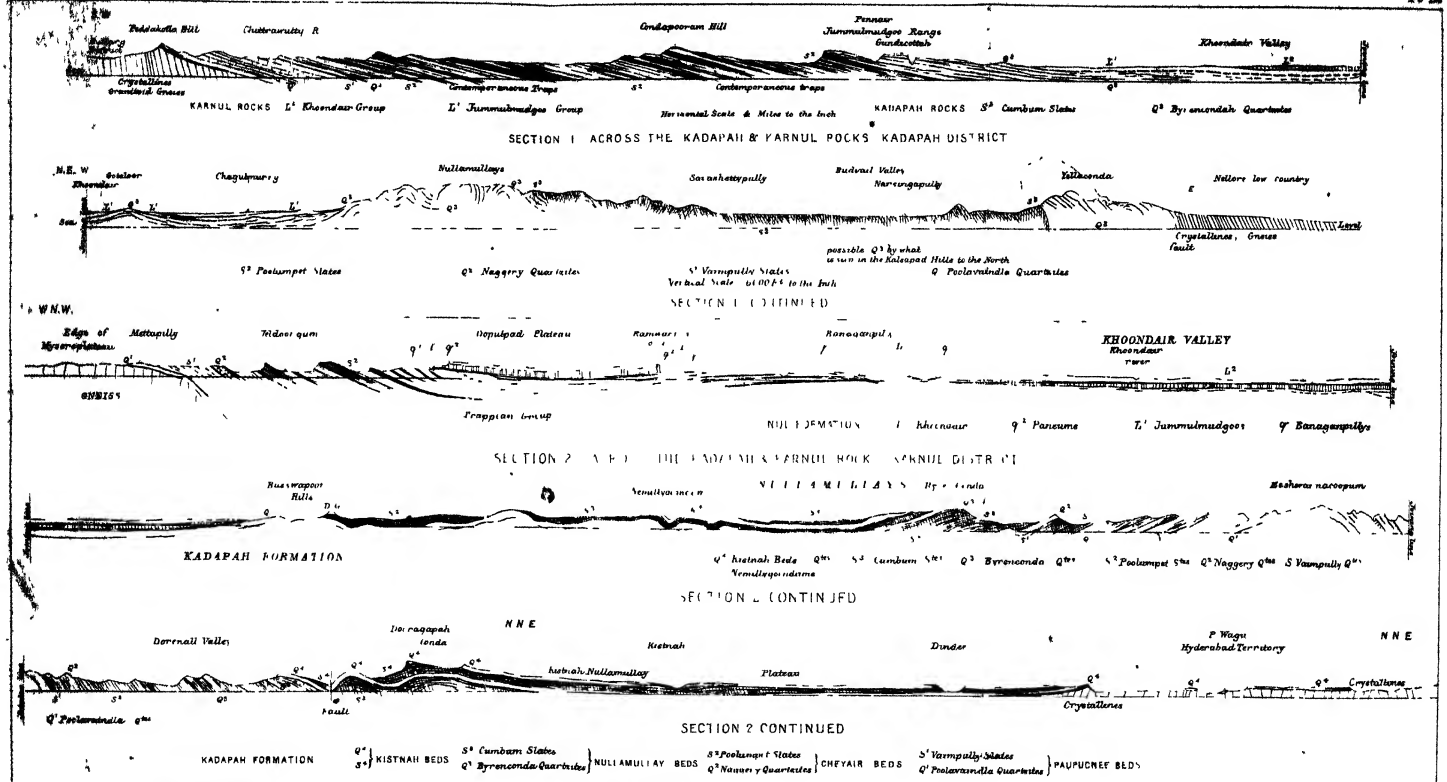


Horizontal Scale 4 Miles to an Inch, Vertical nearly 15000 Ft to an Inch

W King delt

MEMOIRS

OF THE

GEOLOGICAL SURVEY OF INDIA.

The Í'TKHÚRÍ COAL-FIELD, *by* THEO. W. H. HUGHES, F. G. S., *Associate, Royal School of Mines, Geological Survey of India.*

I.—INTRODUCTION.

Incidentally, I alluded in one of the preceding memoirs to the Í'tkhúrí (Eetcooree) field; but I am not aware that besides that instance, and its mention by Dr. Oldham in the "Coal Resources of India," it has ever been noticed in any publication.

The area indeed of its coal-bearing rocks is so very small, that it would probably have escaped examination for some years to come, had not the attention of the Deputy Commissioner of Hazáríbágh, Major Boddam, (who communicated to the Geological Survey the knowledge of the existence of coal at Í'tkhúrí) been specially drawn to the fact by a quarrel which arose between two petty zemindars regarding the proprietorship of the land in which the coal occurred.

The designation of the field is derived from the name of the somewhat considerable village of Í'tkhúrí, which, although outside the boundary of the coal measures, has been preferred as being better known than any of the villages that might have a prescriptive right to contribute a name, as being within the limits of the field.

II.—GENERAL GEOLOGY AND PHYSICAL FEATURES.

In addition to a few patches of laterite, only two series of rocks occur, the Talchír and the Damúdá. Out of the total area of the field, the former series overspreads the whole with the exception of half a square mile or so occupied by the Damúdá, and a similar area occupied by Laterite.

Memoirs, Geological Survey of India, Vol. VIII, Art. 2.

The general features are the same as are elsewhere produced by these rocks; the Talchírs form flat ground; and the Damúdás—which are here represented by only the Barákar group—determine a slight rise.

The country around the field to the east and south is open, but towards the north, the hills and ravines succeed each other so rapidly that cultivation is only practicable in a few localities; and an almost unbroken jungle of 16 miles in breadth extends nearly to the very edge of the Grand Trunk Road. This tract occurs near the confines of Béhár and Hazáribágh, and is well known as being a refuge for 'dákaits.'

The field lies at a very much less elevation than the plateau of Hazáribágh, and corresponds nearly with the level of the Káranpúrá coal-fields, more to the south. Its greatest length is 15 miles, and its average breadth one and a half.

The principal river valley is that of the Mohaní, a stream which forms a part of the drainage system of the Fúlgo (Phoolgo) or Gya river.

III.—Talchír Series.

The contact of the Talchírs with the Gneiss, along the northern boundary of the field, is throughout a great portion of its extent natural; but near Bhédwá and again near Jábér, there is evidence of concentrated crushing. North of Kánhá Chátí, and close to Nowadah, the disturbance is excessive, and there is a quartz-breccia coincident with the line of boundary.

The entire southern contact is natural, and the western and eastern boundaries are of the same nature.

Concerning the succession of the beds, their texture and mineral composition, I have nothing to add to the description given of this group in other areas.

The conglomerate at the base is remarkably well seen near Bárbar and Dárílág; and a very good section of the silts and sandstones is exposed in the Mohaní.

The total thickness of the series, I should not place under 500 feet.

IV.—Damúdá Series.

Barákar Group.—The rocks of the lower group are the only representatives of this series.

There are but two sections in which coal is exposed, one in the Mohaní river, and the other in a tributary of it, that flows between the villages of Daswant and Bargárha.

Mohaní Section.—At the contact of the Talchírs and Barákars in the Mohaní, the dip of the Barákars is as much as 70°. There is also a small fault running east and west.

Ascending—

a. Talchír.
(*Fault*)
b. Barákar.

1.	Sandstone with lenticular masses of coal ...	112′	0″
2.	*Coal* seam	8′	3″
3.	Sandstones curving along their outcrop, and dipping finally to the east.		

The next section—in the tributary of the Mohaní—exposes two seams dipping at an angle of 10° to 11° east. The coal at the outcrop is light and papery, with compressed stems of plants in it.

I could not determine the actual thickness of either seam, but the bottom one appears to be about 4 feet.

Both these beds are higher in the series than the No. 2 coal seam of the Mohaní Section.

V.—Economic Summary.

Coal.—The best of the three seams of coal which this field contains is the 4 feet bed of the section in the small stream. But none of the coals are worth working for any other purpose than for rough work. The average coals would, I consider, contain more than 30 per cent. of ash.

The area of the coal-bearing portion of the field is very small, but its position and the fact of a direct metalled road passing by Ítkhúrí from Chatrá to the Grand Trunk Road, are points in its favour.*

The Public Works Department might very profitably quarry some of the coal, and use it instead of firewood for performing work in connection with the construction of culverts and bridges, not only of the Chatrá road, but also those of the Grand Trunk Road, that are within a reasonable distance.

I heard, when making enquiries on the spot, that coal was profitably carted to Sahibganj (Gya) for burning bricks and lime.

Estimate of coal.—A very rough estimate of the amount of coal available, such as it is, gives about a million and a half to two millions of tons.

Ironstone.—Besides the laterite, much of which contains a large percentage of iron, there are veins of magnetite, and deposits of hæmatite, scattered through the crystalline series.

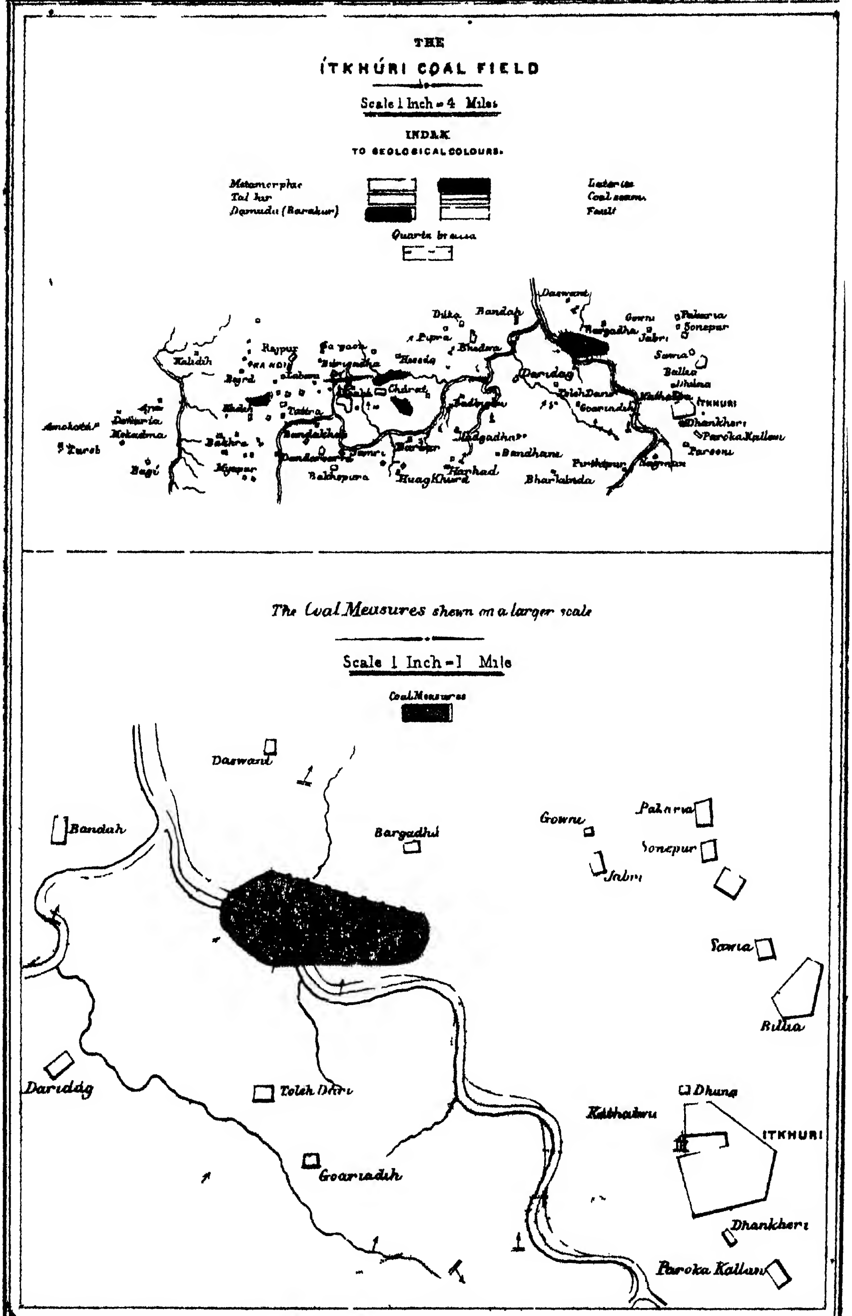
The Barákars in this area do not contain any iron ore; the rocks of the group here belonging to the horizon which comes just below the beds which, in the Káranpúrá field, yield so much of the iron ore worked there.

Sandstone.—I could not recommend the utilization of any of the Damúdá sandstones. They are too free, and too fissile to last long. The crystalline series can yield much stronger and much more ornamental stone.

CALCUTTA,
15*th July* 1870.

* Another small coal-field occurs between Ítkhúrí and Hazáríbágh or nearly so. The nearest village is Chopéh, which is about 8 miles west-north-west of Hazáríbágh town. The field is on the higher level of the Hazáríbágh plateau, about 2,000 feet above the sea. It is very small in area—not more than half of a square mile—and by no means rich in coal.

T. O.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ÍTKHÚRI COAL FIELD
Scale 1 Inch = 4 Miles
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Bakhra
The Coal Measures shewn on a larger scale
Scale 1 Inch = 1 Mile
Coal Measures
Daswant
Bandah
Bargadhi
Gowru
Pakaria
Sonepur
Jabri
Sawa
Billia
Daridag
Toleh Dari
Goariadih
Dhuna
Kathauru
ITKHURI
Dhankheri
Paroka Kallan

MEMOIRS

OF THE

GEOLOGICAL SURVEY OF INDIA.

THE DALTONGANJ COAL-FIELD, *by* THEO. W. H. HUGHES, F. G. S., *Associate, Royal School of Mines.*

Palámaun or Palaaún is a sub-district of the zilla of Lohárdagga, and forms its north-west division embracing an area of about 3,500 square miles.

The larger portion of its surface consists of rocks belonging to the crystalline series, and the smaller portion of separate areas of sedimentary strata.

Of the most important of these areas—the Daltonganj field—I am about to treat in the present report.

Before, however, entering into the special details of the distribution of the different groups of sedimentary rocks that occur within the limits which define this field, I would offer a few remarks about the district of Palámaun generally, regarding its physical aspect, its drainage, its natural products, and its ethnography.

PHYSICAL APPEARANCE.

The physical appearance of Palámaun is essentially that of a hilly district, and it presents a striking contrast to the wide and almost uninterruptedly level countries of Behar and Chotá-Nágpúr, which border it on the north-east and south-east, respectively.

There is a succession of isolated hills and hill ranges, and with the exception of the river valleys of four or five of the larger streams, there are no open areas of any extent which could properly be designated plains.

The average level of the country is about 1,200 feet above the sea, but the highest peaks of the hill range south of the valley of the U'rangá are over 3,000 feet. The contour of the hills is principally dependant upon the nature of the rocks of which they are, in part or in whole, made up; those capped by laterite or sandstone having invariably a flattened summit, whilst those consisting entirely of crystalline rocks present sharp backed ridges and conical peaks which give them a broken and rugged aspect.

The greater proportion of the hills is composed exclusively of metamorphic rocks, but in the west and south-west, in the neighbourhood of the Kanhar river, some of them are capped by massive sandstones and laterite.

The prevalent run of the hill ranges is east and west,—a direction more or less parallel with that of the scarps of the Chotá-Nágpúr and Hazáríbágh table-lands.

Drainage.

In a country so hilly as Palámaun, it follows that streams are innumerable. There are, however, only two principal rivers, the Koel and the Kanhar. Into these, the entire rain that falls in the district, and which travels along fluvial channels, finds its way eventually to mingle with the waters of the Sone.

The Kanhar drains the country to the west, and, flowing northwards, joins the Sone some miles to the east of the old fort of Agori-khas.

The Koel has two large affluents,—the Amánat and the Utrangá; and in the valley of each coal-measure rocks occur.

The navigability of the Koel was practically tested by the Bengal Coal Company, who, some years ago, worked coal at Rajhéra and Pandúa, near the banks of this river. As I have been informed by the Assistant Commissioner, Mr. Forbes, they despatched coal by boats to different stations on the Ganges; but this could only be done during the rains, and the boats they used were very shallow, and are said to have been broken up, after performing the down journey.

The navigation is only seriously obstructed at one place opposite the village of Sigsigé by some gneiss rocks. Were these blown up, the river passage would be cleared and much improved.

PRODUCTS.

The hill sides are clothed in many cases with a thick and luxuriant growth of jungle, and although the trees are rarely large, many of them are of a very useful kind, yielding stout timber, fruits, oils, laks, and kut. Bamboo occurs plentifully, and supplies the best charcoal for iron-refining and gold-working, which is paid for at a higher rate than that made from any other tree.

Large quantities of 'lah' are exported from the district. The most valuable is the product of the kusum *(Schleichera trijuga)*, and next in order comes that of the 'palas' *(Butea frondosa)*; then that of the pípur *(Ficus religiosa)*. The 'lahs' of the bír *(Zizyphus jujuba)*, the babul *(Acacia Arabica)*, and the ním *(Azadirachta Indica)* are only rarely collected. Kut is extensively manufactured from the 'khair' *(Acacia catechu)* principally by the Mallás, Bhogtás, and Bhúíans.

ETHNOGRAPHY.

Of the many castes of Hindús which inhabit Palámaun, the chief is that to which the principal Zemindars belong; the Chéro sub-division of the Rájpúts. Whether they have a perfect right to be classed under the

head of Rájpúts is somewhat questionable, as their features do not exhibit the regularity of their up-country representatives.*

The story that the Chéros tell of their immigration is, that twelve thousand of them took service as soldiers under a Rajah of Palámaun, then dethroned him and conferred the sovereignty upon one of their own tribe. Since that time every *boná-fide* Chéro has borne in addition to his other 'Khitábs' that of Bárah Hazárí.

There are a few Musalmáns; but Palámaun is essentially a Hindú district, distinguished as the home of the Chéros and in a lesser degree of the Desúáris and the Khairwás.† There are many Ooraons and Bhúíans from whose ranks able workmen might be recruited for colliers.

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* It is said that the Chéros are yet to be met with in Kumáon, but my enquiries up to the present date have failed to prove the correctness of this assertion. I was, however, struck by the similarity in the air of a song which I heard some women of the Domra caste near Dhunneea Kot singing, and that with which I was familiar in Palámaun. A Chaprasi also who was with me recognised the air, and on my asking if he had ever heard such an air in Palámaun, he at once replied that he had.—T. W. H. *Almorah,* September 1869.

† The remaining castes are—

Bráhmans.*
Báhman (spurious brahmins with title of Singh).
Beldar * (tank digger).
Bhúían.
Bhogtá (with title of Gunjoo).
Baré (pan-sellers).*
Barhí * (carpenter).
Gwálor.*
Gúlgúliá (beggars).
Gararía * (shepherd).
Súrí (wine-seller).
Sonár * (gold-worker).
Tathéra (copper-worker).
Chamár.*
Kúrmí* (Farmers).
Káist * (scribe).
Koirí * (vegetable-grower).
Kahár * (bearer).
Kúmhár * (earthen-pot-maker).
Kasyárá * (brass-worker).
Khairwá (with title of Singh).
Dhuniá (cotton-worker).*
Dhánuk.*
Dúsád * (chowkedar caste).
Dome.
Dhobí * (washerman).
Dhángar, *alias* Ooraon.*
Desuárí (with title of Singh).
Lohár.*
Mallá * (fisherman).
Málí * (gardener).
Músáhá (beggar).
Mihtar.*
Nao * (barber).
Passí * (toddy-seller).
Rájpút.*
Raj Bhat* (wandering poets of the Hindús).

GENERAL DESCRIPTION.

The Daltonganj field lies partly in the valley of the Koel and partly in the valley of the Amánat; and extends altogether a distance of 50 miles from east to west.

Area.

Its total area is nearly 200 square miles. This statement of its size, however, conveys a very erroneous idea of its value as a coal-bearing district, for out of the 200 miles, scarcely 30 belong to the Damúdá Series.

Boundaries.

The boundaries of the field are very irregular, and for distances of considerable length, they are often so obscured by alluvium that they have been plotted only approximately.

The most eastern extremity is near the village of Loharsí (which is just within the Palámaun boundary after leaving the Hazáríbágh district.

In detail.

The most western extremity is *probably* near Chitorpúr, a mile or so beyond the town of Garhwa. I say *probably*, for the map which I had did not extend far enough to the west to work out the actual limit of the field. But judging from the contracted area of the rocks near Chitorpúr, I suspect that the boundary terminates close by that village.

Hitherto it has been the custom to call this field the Palámaun, (or Palamow,) and not the Daltonganj coal-field. There are, however, many coal-bearing areas within the district of Palámaun, and the name consequently of the Palámaun field as applied to any one of them is not sufficiently distinctive.

Change of name.

The designation would be admissable did any coal-measures occur near the town of Palámaun; but that town happens to be far distant from any locality in which coal-measures exist.

To indicate, therefore, more precisely the geographical position of the field I am now describing, I have thought it better to discard the title of Pálámaun, and in seeking a fresh name to adopt that of 'Daltonganj', from the civil station of Daltonganj, which lies just beyond the southern borders of the field.

Physical appearance.

The surface of the country within the limits of the field is an undulating plain with no rising ground (consisting of sedimentary rocks) that has any pretension to the name of hill. All the inliers of gneiss—and there are several—have been planed down, and although bordering the field there are hills of the same or nearly of the same lithological character, that rise to a height of over 200 and 300 feet and even considerably more above the level of the Amánat, still the metamorphic rocks where within the area of the field have failed to express a definite physical contour distinct from that of the Talchír type.

Drainage.

The principal drainage channels are the Koel and its affluent the Amánat. The latter river enters the field at its eastern extremity about two miles west of Loharsít, and then flows steadily westwards until it joins the Koel five miles north of Daltonganj. None of the sections that it exposes in its passage through the Talchirs and Damúdás are important either geologically or economically; and the same remark applies to those of the Koel.

Amánat.

The tributaries of the Amánat are small streams with the exception of the Jinjoí which may be further noted, as the only one of its important feeders that exhibits coal in its banks.

Koel.

The Koel soon after its entrance into the field runs between high alluvial banks for about two miles, but when it enters into the area of the Barákars its banks lose their conspicuous height.

Its most important tributaries are the Durgáotí with its sub-tributaries; the Sudábah; and the Dánto or Garhwa river. The last mentioned stream exposes no coal, but it displays the entire series of the Talchírs in the west of the field.

DESCRIPTIVE GEOLOGY.

In ascending order, the formations usually developed in the coal fields of Bengal are—

I.—TALCHÍR, (at base).

II.—DAMÚDÁ.

1. Ránigánj.
2. Carbonaceous shales.
3. Barákar.

III.—PANCHÉT.

Upper.

Lower.

In the Daltonganj field, only the Talchír series and the lowest group of the Damúdás occur. I shall proceed first to describe the distribution of each of these series under their different headings, and then treat of the economic value of the field.

TALCHÍR.

This series presents all its well known characteristics, and I need not take up space by describing the lithological peculiarities of its boulder bed, its sandstones and its shales. Suffice it to say that the series is well represented, and that the sandstones predominate over the shales; that the dip of the strata is usually small, and that there are few signs of faulting having occurred.

The contour of the boundary line between the Talchírs and the crystalline rocks is extremely irregular. This is due to the inequalities of the surface upon which the Talchírs were deposited. In only one place could I trace a small cross fault; and the boundaries from one end of the field to the other are natural.

Outliers.

There are numerous outliers of the Talchírs, to prove that the series was formerly deposited beyond the present limits of the actual field. I have not attempted to map them all, as their irregularity of outline would have occupied much time in tracing them out, which could be more advantageously devoted to rocks, the economic importance of which invests them with a superior interest at the present time.

As the Talchírs present no new features of interest, it is not necessary to make references to special localities. Neither is it essential to enter into detail as to the distribution of the series, as the map attached to this memoir is a far better and much readier reference than a description abounding in the names of villages and rivers.

Thickness.

I estimate the thickness of the Talchírs to be on the average about 500 feet. There is no section which I can point to asserting that it gives the data for a satisfactory estimate. But those accustomed to bear in mind and compare the sections which they have studied in different parts of the field, can always form an approximate judgment of the total thickness of the series of rocks which have engaged their attention.

Palæontology.

For the palæontologist there is only a negative interest in the seeming utter absence of anything like fossil remains in the Talchírs of the Daltonganj field. The most careful searches yield nothing, but a consciousness that one's time has been unprofitably spent.

DAMÚDÁ.

This series is represented only by the lower group, the Barákar, which covers an area of about 30 square miles.

Barákars.

Unlike the Talchírs, the Barákars do not exhibit the same constancy of lithological aspect.

The type of sandstone that predominates in the coal-fields of the lower Damúdá valley becomes gradually subordinated as we proceed westward, and in the Káranpúrá field this is no longer the representative rock of the group. I was consequently quite prepared to find in the Daltonganj area the further development of the change which is so noticeable in Káranpúrá. And instead of the typical Barákar sandstone of the more easterly fields, the most prevalent is a false bedded rock with fine and coarse layers of sand deposited often at an angle of nearly 25° with the plane of bedding; texture granular; friable; earthy; slightly calcareous. It breaks away easily under the hammer, and is not adapted for being worked into grinding stones. In colour it is usually more yellow than white; in this respect resembling a very prevalent sandstone of the Ránigánj group. It presents, indeed, a semi-'Barákar' and semi-'Ránigánj' appearance.

With the exception of this change in the aspect of the sandstones there is nothing of any further interest to notice, and I may now describe the distribution of the group and give details of the coals that occur in it.

Distribution of the Barákars.

Beginning the description of them in the east; the lowest beds seen in the Amánat are exposed just north of the village of Kumand.* They are not the usual pebble and grit beds that so generally form the contact rocks, but sandstones that assimilate the variety of which I have given the characters above.

Amánat.

There are but few seams of coal exposed in the Amánat, and those few are of no workable size.

* Koomund or Kumand. This name of this village is not mentioned in the morning, as there is a superstitious dread, current amongst the natives, that by doing so they will not obtain food during the day. It is not until after noon that its name can be mentioned with safety. Before noon it is called 'Burkadih' (? Barkatdih—blessing-giver: Kumand—snare).

Coal at Kumand.

The lowest seam of carbonaceous matter appears in the bank on which Kumand stands. The thickness at its out-crop varies from 6″ to 1′ 6″. Above it is pale, yellowish-white sandstone and shale, having a very gentle dip down the river.

In a field where coal seams are numerous, I should pass over without notice such a bed of carbonaceous shale as this. But where out-crops of anything approaching coal in their look or character are so rarely seen, as in the present district, I have felt it to be a necessity to allude to them; *first*, to prove that they did not escape notice; and, *secondly*, to prevent that importance being attached to their value which is usually the case where coal or the semblance of coal is rare.

Going down the Amánat, a series of sandstones and shales without any coal and with a general low dip makes up the section for more than four miles.

Just before the confluence of the Jinjoí, however, there occur two seams of coal dipping northwards. The highest is only 8″ thick.

The lowest is indicated by 3′ 6″ of black mud at the out-crop, which increases in thickness in the direction of its inclination to nearly 6′ of coal and shale. The angle of dip is not more than 6° to north-north-east, which is low and favourable for working. The quality of the seam is good in parts. There is a slight undulation in the bed, and about 80 yards north of the out-crop there is a small throw fault running north-west-south-east.

The strike varies rapidly within short distances, especially in the Jinjoí river, the section of which will be alluded to presently.

Opposite Singra, on the right bank of the Amánat, the 8″ seam is again exposed, but exhibiting a different section. In one place I measured in descending order—

1.	False bedded sandstone.		
2.	Conglomerate band	0′	3″
3.	*Coal*	1′	2″
3*a*.	Clay shale.		
4.	Fine shalely sandstone.		

Coal at Singra.

Neither the thickness of the coal nor of the conglomerate band is constant (see Fig. 1). The conglomerate disappears entirely a little to the east, whilst the coal within a distance of 60 yards increases from 1′ 2″ to 2′ and then thins out to 4″.

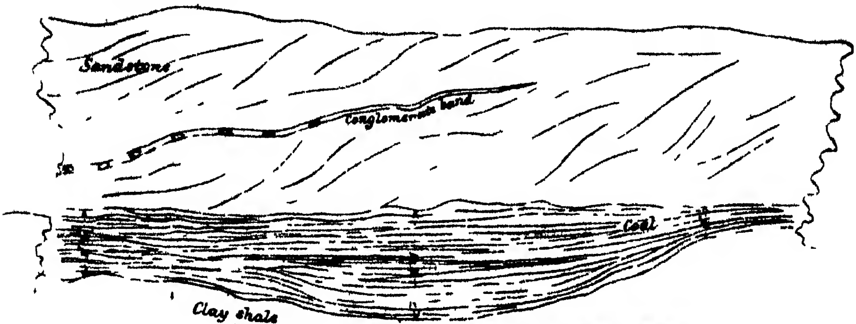

Fig. 1. Sketch of the variation in thickness, &c., of coal and other beds.

The lower seam is not seen in the right bank, but it is exposed together with the upper in the left bank, and here again there is a great difference in the thickness of coal, as compared with that of the former sections.

The upper seam is 3′ 7″ instead of 1′ 2″, made up as follows:—

1. *Coal* seam		3′ 7″
a. Coal, good	1′ 1″	
b. Carbo-micaceous shale, slightly ferruginous	0′ 9″	
c. Carbonaceous shale	5″	
d. Coal, good	1′ 4″	
2. Carbonaceous shale, about . .		3′ 0″

Below the carbonaceous shales come—

3. Sandstone and shale, about	12′ 0″
4. Conglomerate band	0′ 2″
5. *Coal* seam (lower seam)	4′ 6″
6. Carbonaceous shale.	

No. 5 coal is very prominent in the bank under the village of Singra, and is visible to every one crossing the ghât at the mouth of the

Amánat. It has been to a small extent cut into, as it burns with a certain amount of freedom, and wood in the neighbourhood is scarce.

In tracing out the upper and the lower seam to the west, they both exhibit a decrease of thickness; the lower one becomes reduced to 2' 3", there being a proportionate increase to the carbonaceous shale underneath, and the upper one becomes a mere thin band. Neither of these seams crop out in the Koel. They appear rather to occur in a small basin of which Singra forms the western extremity of the major axis.

Jinjoí coal.

Jinjoí river.—In the Jinjoí, these seams again show at the surface, varying in section as they did in the Amánat. The upper seam is of unimportant thickness. It is separated by about 20 feet of sandstone from the lower, which exhibits in two places measured a short distance apart, and a little north of Méiál, the following sections :—

From top to bottom

1st Section.			2nd Section.		
1	Sandstone.		1.	Sandstone	
2	*a*. Coaly shale	0' 10"	2.	*a*. Coaly shale	0 10'
	b. Micaceous clay shale	0' 3"		*b* Micaceous sandy carbonaceous shale	5 0'
	c. *Coal*	4 6'		*c*. *Coal* ..	0 10"
	d. Carbonaceous shale.			*d* Carbonaceous shale	0 4"
3.	Sandstone.		3.	Sandstone	

The variance in the above sections proves that we cannot expect to find any uniformity in the respective amounts of coal and partings of this seam, and that nothing like a reliable estimate could be made as to its yield of fuel. This seam and that above it possess several advantages, *viz.*, their proximity to the Koel, their lowness of dip, and their accessibility from the surface, and as the coal is very fair, the land in which they occur is of value. In the absence, however, of a large quantity of coal, it would be unprofitable for any Company to make these seams the sole basis of their operations.

From Mérál, up the bed of the Jinjoí, to the junction of the Barákars and Talchírs, there are no signs of coal. The rocks for the most part are massively bedded sandstones. They are nearly horizontal, lying at the same low angle as the rocks in the neighbourhood of Joudh, Síká, and Kumand, so that although the distance from the out-crops of coal near Mérál to the base of the Barákars south of Nowadíh is more than three miles, there is not a large intervening thickness of beds.

At the confluence of the Bankar river with the Jinjoí, there are some very typical sandstones of the new variety which characterises the Barákars of this area.

West of the Jinjoí, the country is almost entirely under cultivation.* Scarcely any rock appears at the surface; and neither in the neighbourhood of Húrúhansá, Bijra, Sakhúá, nor that of Kujré, is there any sign of coal or carbonaceous shale.

There is a large quantity of kunkur distributed over this area, ready to be utilised when required.

In the Durgáotí river and its subtributaries there are several out-crops of carbonaceous shale and coal. Most of them are of small thickness, but one or two are of importance.

Durgáotí river.

This river falls into the Koel, below Gadí Khas. Near its mouth and a little inland, about 50 yards from its right bank, two beds of carbonaceous shale appear in some fields. The bottom one is 3′ thick, and the other about a foot. They both dip to the south at an angle of 10°.

From Gadí to Katutíá there is nothing but shales and sandstones; the latter are of the new type of Barákar sandstones, being false bedded and massive; with fine and coarse grained layers irregularly distributed

* The crops being "chuna" and "mussoorse" dals.

through the rock; texture friable; composition somewhat calcareous and micaceous.

Opposite the village of Katutíá, where the Durgáotí makes several sharp bends, two seams of what appears at the out-crops to be only carbonaceous shale, occur. Of these the higher in the series is about 6′ thick and the lower 3′. Each seam is too indistinctly exposed to say positively what its real thickness is, and whether it contains any coal.

They are both in the same strike as the beds further west near Pandúá, which have yielded coal, and, therefore, it will not be surprising if in sinking on the seams in the Durgáotí some should be met with. The amount of dip is not by any means clear; the inclination, however, is small, and does not appear to exceed 5°. The direction is westerly.

Subtributaries of the Durgáotí.

These, which exceed six in number, unite near the village of Lohra to form one river.

The most easterly is the Basú nallah. Before entering the main assemblage of Barákars, it flows through a small body of that group situated west of Saraiá. Thereis one bed of coal exposed in its banks measuring 1′ and dipping at an angle of 9° to the north-east. Below it occurs clay shale, and above it fine grained sandy sandstone tinged slightly with a pink colour. This was the only coal which I could find, and I think none other exists, as I searched carefully.

This little area of Barákars forms a basin of irregular shape, the synclinal axis of which passes not far from the northern boundary. The general dip of the strata is northwards, and it happens that a greater thickness of beds is exposed dipping in that direction than to the south; there is, therefore, some ground for suspecting either the existence of a fault or attributing to overlapping the want of agreement in thickness on either side of the axis. The section is not clearly seen throughout, and as I met with no actual mechanical evidence

of a fault, nor noticed any special disturbance in the rocks, the more rational explanation appears to be that of overlap; as being consistent with the view formed of the conditions under which the bottom beds of the Barákars were deposited.

The remaining subtributaries in which coal is seen flow between the villages of Lohra and Pandúa. There are minor beds of coal, but there is one principal seam which occurs in them all, and is that which to some extent, was formerly worked by the Bengal Coal Company. The sections visible, as might be expected from the experience gained of other seams, do not correspond to each other, and it is only the horizon at which they occur that gives some reason for supposing them to be those of the same seam.

The rocks undulate very much and rise up often in swelling bosses, producing a repetition of beds and irregularity in their line of out-crops. In working the large seam this occurrence of bosses will cause great inconvenience, and will be likely to throw a miner out in his calculations regarding the lie and position of the coal.

Pandúa seam.

This seam is only represented by black mud in the banks of the first nallah west of Lohra, but in the next (nallah) there is a more distinct section. The following measurements were made, where the rocks happen to be clearly exposed with a northerly dip of 6°. But as I said before, there is considerable undulation of the strata in this locality, and, therefore, the direction is not constant for more than short distances:—

(Descending).

1. *Coal*		...	1′ 0″
2. Shale		...	8′ 0″
3. Sandstone (about)		...	15′ 0″
4. *Coal* seam		...	8′ 2″
a. Coaly shale	0′ 6″		
b. *Coal* (good)	8″		
c. Coaly shale	1′ 0″		
d. Carbonaceous shale (about) ...	6′ 0″		

The above section of the coal seam No. 4 is exposed a few yards inland of the stream in the left bank. The whole of the carbonaceous shale *(d)* was not seen.

In the nallah immediately east of Pandúa there is an old quarry on the Bengal Coal Company's ground. The coal seam here has a small dip, and undulating slightly, its out-crop extends for some way down the bed of the river. There is no opportunity of measuring it in this place, but it appears at the surface near the boundary of the Barákars and Talchírs, and is there fully exposed.

The dip is 14°; and the section in descending order is—

1.	Sandstone, yellowish.						
2.	*Coal* seam					15′	9″
	a.	*Coal* and coaly shale	3′	5″			
	b.	Carbonaceous shale	3′	6″			
	c.	Yellow sandstone	1′	4″			
	d.	Carbonaceous shale	7′	6″			

To test the quality of this coal, which is about the best in the field, I burnt some of it that was stacked near the quarry. It left a large quantity of very red ash, did not burn freely, and gave out a strong smell of sulphur, so that it cannot rank as a first class coal. In justice, however, I must mention that it had been exposed for more than five years.

At a short distance from the quarry, down the river, there is a burnt out-crop of carbonaceous matter, and below it is a small bed of coal.

The continuation of the large seam 15′ 9″ can be traced through the jungle, south of Pandúa, to the Sádábah river, where there is a well exposed section in the left bank, about three quarters of a mile from the confluence of the Sádábah and Rajhéra streams. The dip which is 11°, and in a northerly direction at this spot, is not constant, and changes within a distance of a few yards owing to swells.

The following is the order of succession of rocks in descending section :—

1.	Sandstone (about)		...	12′ 0″
2.	Fine argillaceous shale (about)		...	8′ 0″
3.	Red ferruginous shale...		...	1′ 10″
4.	Argillaceous shale		...	3′ 0″
5.	Slightly carbonaceous argillaceous shale ...		...	5′ 0″
6.	*Coal* seam		...	11′ 0″
	a. Coaly shale	2′ 4″		
	b. *Coal* (good)	0′ 1″		
	c. Carbonaceous shale	2′ 1″		
	d. Coaly shale	0′ 8″		
	e. Carbonaceous shale	0′ 10″		
	f. *Coal* and coaly shale (not all seen) ...	5′ 0″		
7.	Sandstone.			

The whole of *f* is not seen, so that the seam is somewhat thicker than 11 feet. I think 13′ to 14′ may be assigned as its thickness. The sandstone No. 7 is almost the bottom bed of the Barákar group.

The above section is the last measurable one of No. 6. The seam, however, can easily be followed out as far as the bungalow at Rajhéra. Beyond that point, there is no trace of it at the surface, but there cannot be much doubt as to its extension in a westerly direction. The seam appears to be as subject to swell at Rajhéra as it is in the neighbourhood of Pandúa, and in addition, there is evidence of a greater degree of disturbance, especially north of the bungalow. At the bend of the river, between the two villages called Rajhéra, the rocks have a high dip to the south, and I think there is a fault running more or less east and west. This does not affect the coal seam, but it shows the course which we may expect faults to pursue.

Coal at Rajhéra.

Combustion of some of the coal has taken place that has converted the shale associated with it into a brick red rock which is similar to that seen at the burnt out-crop in the nallah east of Pandúa. Both these burnt out-crops, I consider, belong to one seam.

The only other out-crop in this field of what may really be termed coal occurs in the Rajhéra river, about 120 yards from its confluence with the Koel. It is best seen in the left bank, and at the place of exposure measures 3′. The coal it contains looks of excellent quality, and I would strongly advise its being opened out.

At first I thought this seam identical with the one at Rajhéra, but the difference in their respective thickness is great, and the sandstones with which they are associated are distinct in character.

Its position in the series will be higher than that of the Rajhéra seam. There is a bed of carbonaceous shale in the Koel measuring 3′ 6″, which may be the extension of this 3′ bed. It occurs in the right bank.

The foregoing remarks end the special descriptions of the different seams of coal with which I met during the investigation of the Daltonganj field. There are some out-crops of carbonaceous shale that I have not referred to, as they are useless for any economical purpose; their position, however, is indicated on the map.

The distribution of the Barákars beyond Rajhéra presents no feature of any interest. The principal rocks are sandstones, which are massively bedded, dip at small angles, and contain some lime in their composition.

The trend of the boundary is north-westerly near Busna, corresponding in a measure to the contour of the Talchírs; it then turns southward, crossing the Jhurha nadí, about a mile from its junction with the Koel.

Organic remains.—Nothing but vegetable remains occur; and these are neither distinctly preserved nor are they numerous either as to species or individuals.

Igneous rocks.—There is only one case of intrusion of trap. In the Jinjoí river, just at the border of the field, a dyke appears in the Talchír series.

In contrast to the absence of igneous rocks in the Damúdá and Talchír series, is their abundance beyond the limits of the field. Along the southern boundary near Panki Lohársí, Kúndrí and elsewhere, there are little hills of what I would call greenstone; and again on the north there is a very conspicuous hill called Kálápahár, entirely constituted of broken pieces of the same rock.

Economic Summary.

On account of the limited area occupied by the Barákars and the paucity of coal seams, the economic value of this field is small. There is indeed but one workable seam—that which occurs at Pandúa and Rajhéra; and in calculating the available yield of coal, I would leave out of consideration the seams at Singra and the one in the Sádábah river, as they would only be worked for supplying fuel should their proximity to a lime or brick-kiln give them the advantage of position over the Rajhéra seam. For any demands from a distance that may be made upon the Daltonganj field, the Rajhéra (or Pandúa) seam only would be available, and as I question whether any local demand will ever arise, a computation of its yield will give the true index of the value of the field. The area covered by this seam may be assumed to be three miles by one, and assuming that there is 6 feet of coal, the yield would be 18,000,000 tons. But a considerable correction has to be made on account of the specially irregular character of the coals of this field, and on account of waste, &c., in working. From the 18,000,000 tons of available coal I do not think a deduction of $\frac{6}{10}$ would be excessive, and we shall have remaining 11,600,000 tons of available coal.

Although this amount is small, it is sufficient to supply for the next 50 years any centres of economy that might find it advantageous to draw their fuel from the Daltonganj field.

In the Office of the Geological Survey, the following analysis of the Pandúa coal, which had been exposed for several years, was made by Mr. Tween, *viz.* :—

Quality of coal.

Carbon	64·4
Volatile matter	22·4
Ash	13·4

In the "Gleanings in Science," page 283, vol. III, the following analyses are recorded :—

1. Slaty coal, S. G.	1·482	
Water expelled on sand bath		9·1
Carbon		52·1
Volatile matter		37·4
Ashes		10·5
Percentage of ash in coke		16·8
2. Coal without lustre, S. G.	1·419	
Water expelled in sand bath		7·1
Carbon		54·1
Volatile matter		36·4
Ashes		9·5
Percentage of ash in coke		14·9

Considering that the coal assayed by Mr. Tween had been exposed for several years, and possibly some of the volatile matter had been dissipated, there is a close approximation to the results obtained and recorded in the Gleanings in Science. I have little doubt that these assays are of the Singra coal, and if so, it shows that the coal of the field is of pretty equable quality.

Ten to thirteen per cent. of ash is in excess of the better kinds of Damúdá coal, but for ordinary purposes, this amount of inorganic matter is no serious drawback. The coal of this field is capable of performing the duties which Ráníganj coal has hitherto accomplished.

I have already mentioned that the Bengal Coal Company once worked the coal at Rajhéra and at Pandúa. Several shafts have been sunk, and two of them are of large dimensions. The finest is one south of the village of Pandúa, which is 13 feet in diameter. The water in it stood at a level of 50 feet below the surface of the ground on the 18th February 1869.

Since 1862, operations have been suspended, but now that the project of the Sone canal has been sanctioned, a demand for coal may arise to bring into activity a branch of industry which so materially affects the welfare of a people.

A road has lately been constructed to facilitate the carriage of coal from Rajhéra and Pandúa. It runs in a north-westerly direction, skirting the hills which border the Koel. It diverges from the Koel near Muhammadganj, and passing by Haidarnagar and Japlá touches the Sone near Búdwá.

The following returns of the coal raised between the years 1859 and 1862 are copied from the "Coal resources and production of India":—

1859	...	...	...	...	28,648 Maunds.
1860	.	. .	...	...	30,900 „
1861	.	...	..	...	33,343 „
1862	.	...	. .	...	43,772 „

The Talchir series can furnish the builder with excellent fine grained sandstones, presenting every desirable shade of color. Of the Barákar sandstones there is little to be said in their favor, as they are generally too friable to be useful.

Building stones.

Iron ores—occur abundantly beyond the limits of the field.

Kunkur.—This is so plentiful in many places that it completely obscures the rocks under it. There is scarcely any part of the field where it may not be found.

History of the Field.

The credit of the discovery of this field is due to Mr. A. Prinsep, but the first reliable account of researches is from the pen of Captain Franklin, dated 24th April 1829.

The field was more fully explored by Captain Sage in January 1830, and his sections* correspond very closely to those published in the present memoir.

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* Gleanings in Science, Vol. II, p. 219.

The geological survey undertook the examination of the coal-measures late in 1867, and again in the season of 1868-69.

In addition to the remarks which are contained in the preceding pages, I have some to make upon areas of sedimentary rocks which occur at Sathbarwa, and around the village of Látiahar.

1*st.*—*Sathbarwa* is a cháti on the Daltonganj and Ranchi road, and is about 15 miles from the former place.

Talchírs crop out in the Maila nadí, and on the road: I saw no rocks belonging to a higher series.

2*nd.*—*Látiahar.*—This village is another cháti on the Ranchi road, and its name may be appropriated to distinguish the coal-field in which Látiahar occupies, roughly speaking, a central position.

The development of the Panchéts is much in excess of the other series which occur, *viz.*, the Talchír and Damúdá. The Panchéts that I saw were restricted to the upper division, (which in one of my former manuscript reports, I suggested, might be the equivalents of the Mahadévas), and the characters that distinguish them most are their ferruginous composition and the great prevalence of pebbles.

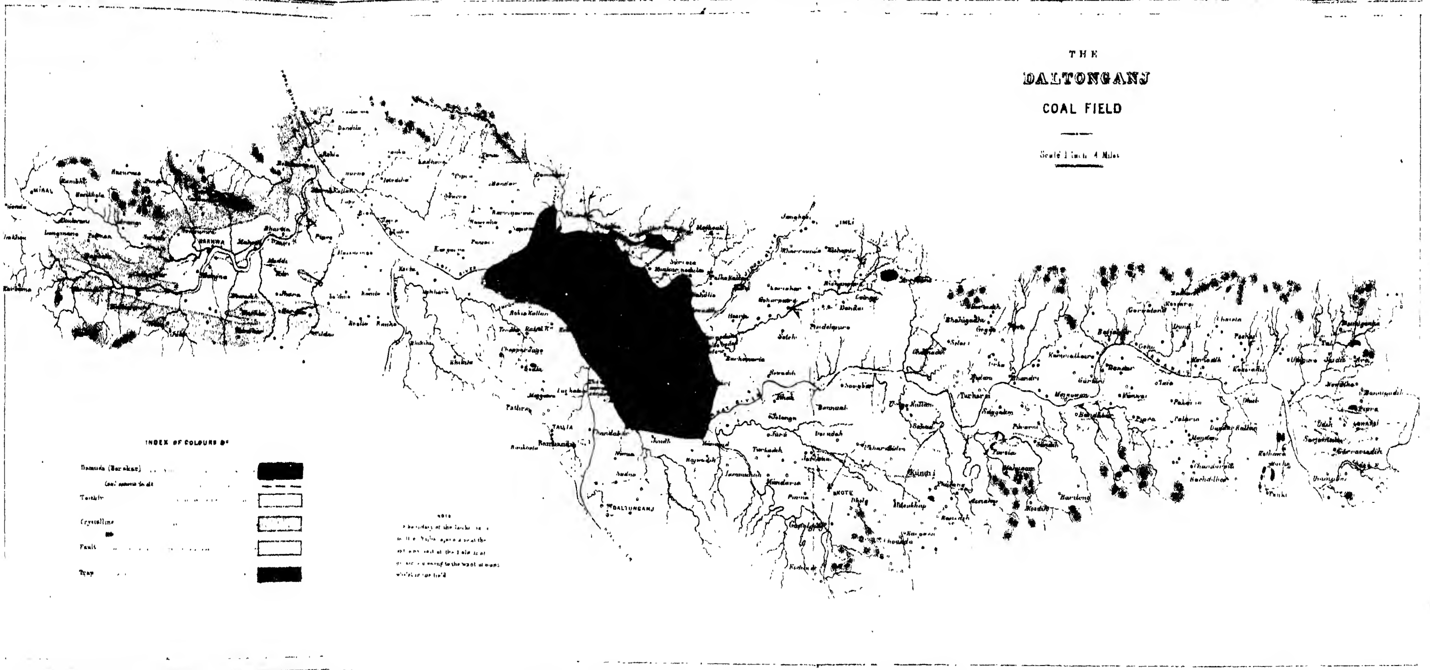
In many places the Panchéts rest directly upon the Barákars.

West of Látiahar the aspect of the rocks at the base of the section in the river is peculiar. They are really Barákar beds, but distinguished in a great measure by iron. The iron which further to the east segregated and formed separate bands, in this locality has become generally distributed through the rocks. This prevalence of iron gives to the series a similarity of aspect, by which attempts at sub-dividing are defeated.

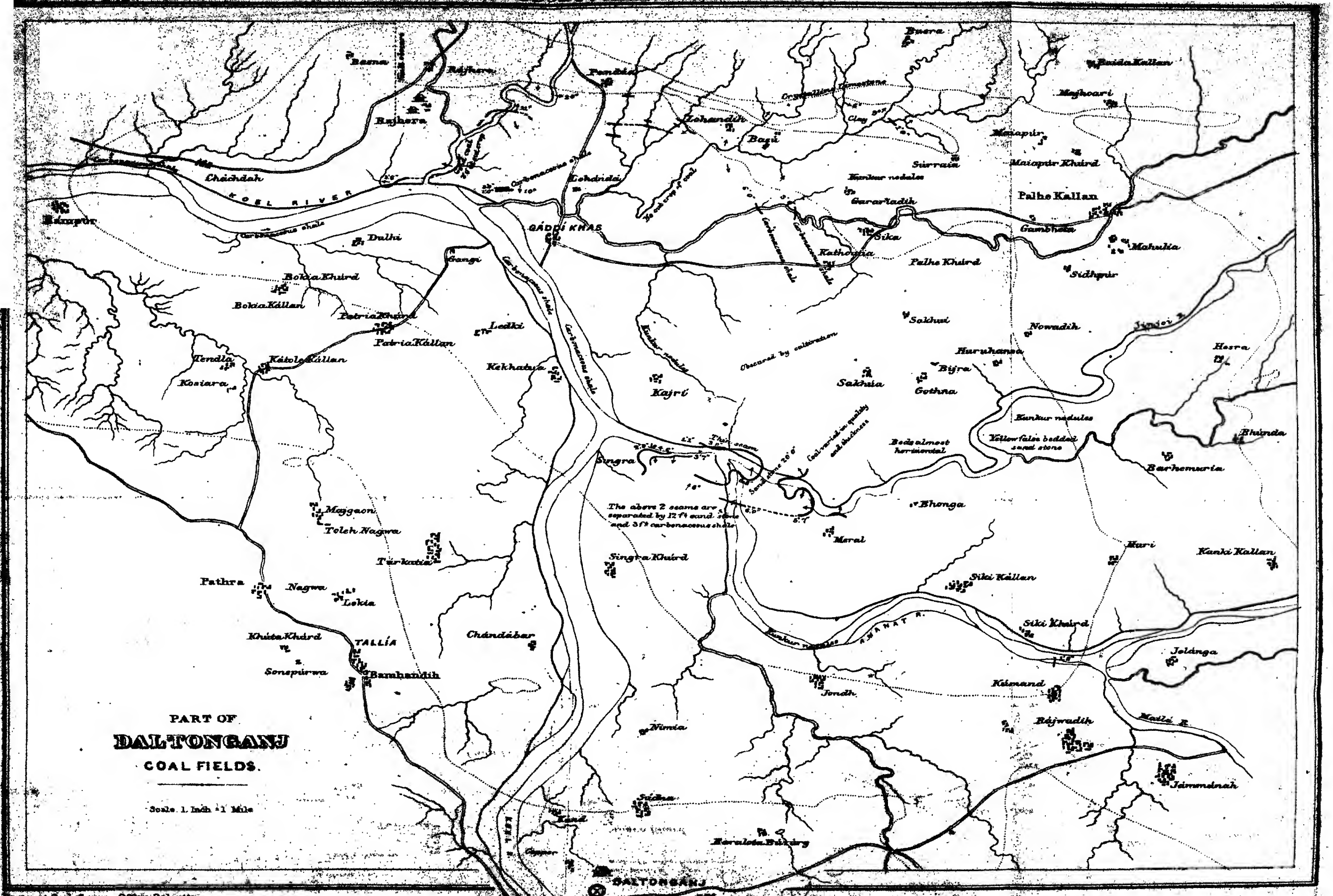
There is little workable coal; many coaly shale beds crop out in the Uránga near Zalim, and there are carbonaceous out-crops in the neighbourhood of Balú Nagar.

Areas of Talchírs in the Hazáribágh District.—There are two areas on the Balúmath and Chutro road, the larger of which occurs near Sindwári.

18*th September* 1869.



Lithographed in Colors at the Surveyor General's Office, Calcutta, November 1870.



Drawn in Geol. Survey Office Calcutta.

MEMOIRS

OF THE

GEOLOGICAL SURVEY OF INDIA.

THE CHOPÉ COAL-FIELD, *by* V. BALL, B. A., *Geological Survey of India.*

The small coal-field which forms the subject of the following account is situated in the valley of the Mohani river, about eight miles in a direct line, a little north of west, from the station of Hazáríbágh. It is thus well within the limits of the Hazáríbágh plateau, and its elevation is scarcely less than that of the station, or about 2,000 feet above the level of the sea.

Name.

The principal village in the vicinity, Chopé, has furnished the name which has been adopted to indicate this area of coal-measure and associated rocks.

Discovery.

During the early part of last year (1869), Dr. J. M. Coates, Superintendent of Jails in Hazáríbágh, devoted a considerable amount of time to the examination of the country surrounding the station of Hazáríbágh. With the help of natives he succeeded in discovering several deposits of iron and lime, and also the seam of coal to be described in the following pages.

Mr. Donaldson's report.

In April 1870, this coal was visited by Mr. Donaldson, who was deputed by His Excellency the Viceroy to report whether it would be advisable for Government to utilize the iron ore, limestone, and coal in the neighbourhood of Hazáríbágh in the manufacture of iron by means of convict labor.

His account of it is as follows:—

"About three miles to the westward of Belhargudda, on a branch "of the Mohani Nuddee, there is a small deposit of coal of very "poor quality."

Although this was the first instance of coal measure rocks being found on any of the *plateaus* of Chota Nagpúr,* they had been met with previously at an equal elevation by Mr. Medlicott, "capping the "isolated Madaghir hill, which lies three miles to west of the Káranpúrá "field, and about four miles north of the table land."†

The economic importance attaching to the occurrence of coal so near the station, and the bearing which this discovery exercises on the general hypothesis as to the origin of, and connection between, the several coal-fields, combined to render it desirable that the locality should be visited and reported upon by a member of the Geological Survey at the earliest opportunity. Accordingly pursuant to my instructions I visited the Chopé coal when proceeding to my season's work in Sirgúja and Odeypúr.

Area.

The area occupied by the coal measures and underlying Tálchírs which constitute the Chopé coal-field is of an irregular triangular shape, covering about three-fourths of a square mile. It is thus the smallest detached coal-field known in India, being smaller than the one near the village of Mehurpúr, six miles north-east of Súri in Birbhúm.

The coal-field is approached from Hazáríbágh by a road which, for the most part, passes over alluvium, but in its vicinity there are

* There are in Hazáríbágh two coal-fields north of the plateau, Kurhurbari and Itkúri, and four south of it, Bokáro, Ramgurh, and North and South Káranpúrá. Subsequently to the discovery of the Chopé coal, Mr. W. T. Blanford was informed by the Raja of Jushpúr that coal existed in his district, which would be at an elevation as great, possibly greater than that of the Hazáríbágh plateau. This locality has not yet been visited.

† M.S.S.

occasional outcrops of metamorphic rocks, some of which are accompanied by extremely rich deposits of iron.

For some distance on either side of the Mohani the ground is much broken up into ravines and covered with jungle, both of which tend to obscure the position of the boundaries. Fortunately the greatest depth of the area from north to south is traversed by the Mohani, the section in which affords a clue to the structure otherwise completely hidden.

Section.

The section in this stream, in so far as it refers to the coal-field, commences with a fault a short distance beyond (north of) the mouth of the Torar stream. This fault is well marked both by the crush up and abrupt approximation of the rocks on either side and by a dyke of pseudomorphic quartz which is similar to that often found accompanying lines of fracture. This fault has lowered to the level of the gneiss a few feet of coal-measure sandstones, and shaly and stony coal with some ordinary carbonaceous shales.

The actual thickness of the coaly portion could only be roughly estimated, owing to the crushing up, as being about four feet. Its utter uselessness as a source of fuel, however, renders this an unimportant point for determination.

Proceeding northwards up the bed of the river, the section soon discloses the fact that these rocks form a basin or trough, and at a distance of about one hundred and sixty yards the coaly shale again crops out with a dip of 15° to south-south-west. Beyond this after a short interval there is an anticlinal lump formed of the Tálchír boulder beds. Owing to this interval, in which sand is alone seen, the character of the boundary between these adjacent rocks is obscured.

At first sight the junction appears to be natural, but on examining the section further north on the other side of the anticlinal, quite a

different set of beds which seem to be Barákars appear, and there is no repetition of the coaly shale. This fact renders it probable that there is a parallel fault bounding the trough or basin of coal rocks on the north to that on the south by means of which the Tálchírs have been brought to the surface, and Barákars higher than those actually seen in contact, and resting on the Tálchírs on the north side of the anticlinal have, on the south, been let down and preserved.

This view of the structure will be more clearly understood by reference to the accompanying sketch section (see Map).

Further up the bed of the river Tálchírs, again resting upon gneiss, appear with a slight roll. After which several short reaches exhibit sections of gneiss, and then a spit-like prolongation of the Tálchírs, bounded on the north by a north-east south-west fault, strikes into the bed of the stream. Thence northwards as far as the village of Bandgaon, granitic and hornblendic gneiss are the only rocks exposed in the bed of the Mohani.

Itkúri field.

Mr. Hughes when examining the Itkúri field found gneiss south from it as far as the village of Pornadih, or about twelve miles north-west of Bandgaon. Whether coal rocks appear in the interval has still to be determined when the general examination of the district shall be taken up.

BARÁKAR GROUP.

The description of the section above given leaves but little to be said specially under this head.

According to the interpretation of the section adopted, there are two distinct portions of the Barákar group existing in this field. One, the higher, let down by a pair of parallel faults, and the other resting immediately on the Tálchírs.

In the former the coal or coaly shale which has attracted attention to this locality lies in a trough dipping at first 35° to 10° west of north, falling rapidly to the horizontal, and where seen near the Tálchírs, it has a dip in the opposite direction of about 15°. The coal, as stated above, is about four feet thick, the remaining forty to forty-five feet of Barákars being made up of carbonaceous shales and sandstones. As to the poor quality and extremely limited amount of this coal there can be no doubt; possibly a portion might be made use of for brick and lime burning, but I regret to say that I can give no hope of a useful fuel for general purposes being found in this locality. It will, I believe, be cheapest in the end for those in Hazáríbágh who may require coal even for the inferior purposes above mentioned to draw it from the more distant, but vastly, richer Bokáro and Káranpúrá fields.

Coal seam.

North of the anticlinal there is a thickness of sixty to seventy feet of sandstones and pebble beds, some which are not unlike rocks which occasionally occur in the Tálchírs, but as they also resemble Barákars, and the interpretation of the section which has been adopted is sufficient to explain their existence as such, I am inclined so to regard them.

The boundaries between the Barákars and Tálchírs on the east and west are extremely obscure on account of the superficial deposits, ravines, and jungle.

Tálchírs.

In the centre of the Barákars occurs the anticlinal lump of Tálchír boulder bed already alluded to. It abounds in jaspery-looking masses of iron ore and gneiss boulders of the ordinary character.

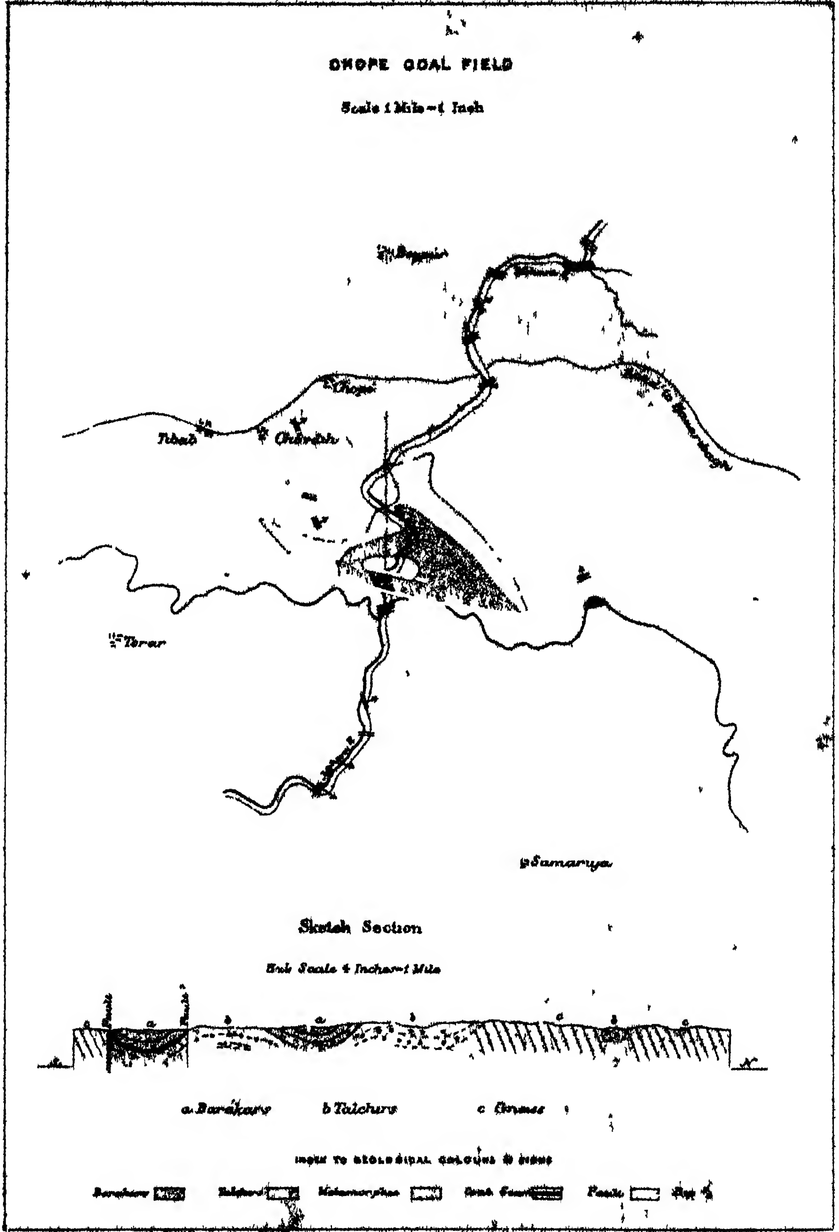
Skirting the Barákars on the east, west, and north, there is a more or less clearly exposed strip of Tálchírs, the northern extension of which is rather abruptly terminated by a fault.

These rocks consist chiefly of greenish sandstones and the boulder bed—the shales being imperfectly developed.

Metamorphic Rocks.

The metamorphic rocks in the vicinity of the above-described field consist, for the most part, of granitic and hornblendic gneiss with occasional rich lodes and interstratifications of magnetic iron ore.

Hazáríbágh,
November 1870.



Lithographed in Colors at the Surveyor General's Office, Calcutta, July 1871.

ERRATA.

Page 12, line 15, *for* an unconformity, *read* no unconformity.
,, 16, ,, 12, ,, Baukrapett, ,, Baukrapett: and throughout the report.
,, 17, ,, 3, ,, Kiskumbady, ,, Kirkumbady.
,, 19, ,, 10, ,, south, ,, north.
,, 25, ,, 7, ,, Porenaumlah, ,, Poremaumlah.
,, 26, ,, 9, ,, 1,800, ,, 2,800.
,, 26, ,, 21, ,, 2,000, ,, 3,000.
,, 29, ,, 8, ,, farely, ,, fairly.
,, 35, ,, 6, ,, extension, ,, extensive.
,, 43, ,, 15, ,, shales, ,, slates.
,, 56, ,, 21, ,, ever, ,, even.
,, 59, ,, 6, ,, Novenabode, ,, Noornabode.
,, 59, ,, 28, ,, on the village, ,, from the village.
,, 16, ,, 17, *read*, the bed shows a double dip, as in the section below.
,, 70, last line in note: the building is, we believe, for the Madras Presidency College, not for the University.
,, 87, line 11, *for* condition, *read* description.
,, 98, ,, 23, ,, 20 feet, ,, 30 feet.
,, 101, ,, 21, ,, 10 Rs., ,, 40 Rs.
,, 101, ,, 22, ,, 40 ,, ,, 10 ,,
Pages 128 and 129, the second note on p. 129 should have been referred to line 6 from bottom on p. 128.
Page 142, line 1, *for* 21*a*, *read* 21*b*.
,, 142, ,, 4, ,, 21*b*, ,, 21*a*.
,, 146, ,, 24, ,, Bogroo, ,, Booga.
,, 148, last line, ,, Lorepoor, ,, Zorepoor.
,, 153, line 21, ,, specular, ,, hæmatitic.
,, 156, last line, ,, gniess, ,, gneiss.
,, 192, line 5, ,, Silica 31·65, ,, Silica 81·65.
,, 212, last line in note, ,, 3,500, ,, 3,133.
,, 216, line 3 from bottom, ,, Konayon, ,, Koyamon.
,, 218, ,, 34, ,, Porenaumla, ,, Poremaumlah; also on p. 222, fig. 37, and on p. 223, line 6, and elsewhere.
,, 252, ,, 21, ,, Parawaltoon, ,, Parawattum.
,, 254, fig. 42, ,, Scale 2 miles, ,, Scale 4 miles, &c.
,, 260, line 5 from bottom, ,, 40, 41, 42, 43, ,, 43, 44, 45, 46.
,, 272, ,, 19, after Gozarpully, *insert* (or Gazulpully).
,, 273, ,, 20, *for* seams, *read* seems.
,, 277, lines 6 & 5, from bottom, ,, Yeldoorly, ,, Yeldoorty.
,, 277, line 6, ,, specular, ,, hæmatitic.
,, 282, ,, 7, ,, and, ,, end.
,, 283, ,, 2, ,, Yeldoorly, ,, Yeldoorty.
,, 297, ,, 11, ,, ten and half, ,, ten and a half.
,, 297, ,, 16, ,, Kunlamuddi, ,, Kantamuddi.
,, 299, ,, 4 from bottom, ,, Ballagurigo, ,, Ballagariga.
,, 303, last line, ,, Ditto, ,, Ditto.
,, 303, line 14, ,, Laladurgum, ,, Saladurgum.
,, 309, ,, 8, from bottom, ,, north-north-west, ,, south-south-west.